December 19, 2008

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of:	)	
	)	
U.S. Department of Energy	)	Docket No. 63-001
(High Level Waste Repository)	)	
	)	
	)	

THE NUCLEAR ENERGY INSTITUTE'S PETITION TO INTERVENE

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THE NUCLEAR ENERGY INSTITUTE'S PETITION TO INTERVENE

I. INTRODUCTION

In accordance with 10 C.F.R. § 2.309, the Nuclear Energy Institute ("NEI") respectfully seeks leave to intervene in the proceeding on the application of the Department of Energy ("DOE") for a license to construct a high level nuclear waste repository at Yucca Mountain, Nevada. Except as stated in specific contentions herein, NEI supports issuance of a license for the proposed facility, supports the DOE license application, and seeks to participate on issues raised by other parties that contest the license. In accordance with the Commission's regulations, NEI herein also specifies specific contentions for hearing.

II. NEI'S STANDING TO PARTICIPATE

A. Standing as of Right

In accordance with 10 C.F.R. § 2.309(d), NEI provides the following information:

Name of Petitioner: Nuclear Energy Institute

Address: 1776 I Street, N.W.
Suite 400
Washington, DC 20006

Telephone Number: (202) 739-8000

NEI has a clear and direct interest in this proceeding, based on its representation of the interests of its members arising under the Atomic Energy Act, 42 U.S.C. §§ 2011 *et seq*. ("AEA"), the National Environmental Policy Act ("NEPA"), 42 U.S.C. §§ 4321 *et seq*., and the Nuclear Waste Policy Act of 1982, 42 U.S.C. §§ 10101 *et seq.* ("NWPA").

NEI is a not-for-profit corporation under Section 501(c)(6) of the Internal Revenue Code, and is the policy organization responsible for representing the nuclear industry before the executive, judicial and legislative branches of government on regulatory, technical and legal issues that generally affect its members. NEI's members include all entities licensed to operate commercial nuclear power plants in the United States, nuclear power plant designers, major architect/engineer firms, nuclear fuel fabrication facilities, nuclear materials licensees, unions, and other organizations and entities involved in the nuclear industry or likely to be involved in construction and operation of the Yucca Mountain repository. As such, among NEI's members are the former and present NRC operating licensees that have generated used nuclear fuel from commercial power operations and that presently store used fuel at the sites of both currently operating and shutdown power reactors. In accordance with the NWPA, used nuclear fuel from nuclear power plants operated by these companies is to be accepted by DOE and will be disposed of by DOE at Yucca Mountain if the site is licensed by the NRC pursuant to the regulations in 10 C.F.R. Part 63.[1]

Under longstanding NRC precedent, an organization may properly base standing on its members' interests ("representational standing"). To do this, the organization must demonstrate that at least one individual member has standing to participate, in accordance with the three-part judicial test. *Houston Lighting & Power Co.* (Allens Creek Nuclear Generating Station, Unit 1), ALAB-535, 9 NRC 377, 390-93 (1979).[2] The organization must (1) identify at least one of its members by name and address; (2) demonstrate how that member may be affected by the licensing action; and (3) show (preferably by affidavit) that the organization is authorized to request a hearing on behalf of that member. *Yankee Atomic Elec. Co.* (Yankee

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1 *See, e.g.*, 42 U.S.C. § 10131(b)(2).

2 Based on the "case or controversy" limitations of Article III of the Constitution, judicial concepts require that the petitioner show: (1) a distinct harm that constitutes injury-in-fact; (2) that the injury can be fairly traced to the challenged action; and (3) that the injury is likely to be redressed by a favorable decision. *Bennett v. Spear*, 520 U.S. 154, 167 (1997) (citing *Lujan v. Defenders of the Wildlife*, 504 U.S. 555, 560-61 (1992)).

Nuclear Power Station), LBP-98-12, 47 NRC 343, 354; *aff'd in part, rev'd in part*, CLI-98-21, 48 NRC 185 (1998); citing *Yankee Atomic Elec. Co.* (Yankee Nuclear Power Station), CLI-96-1, 43 NRC 1, 6 (1996). Moreover, an organization must show that: (1) its members would otherwise have standing to sue in their own right; (2) the interests that the organization seeks to protect are germane to its purpose; and (3) neither the claim asserted nor the relief requested requires an individual member to participate in the organization's lawsuit. *Private Fuel Storage*, (Independent Spent Fuel Storage Installation), CLI-99-10, 49 NRC 318, 323 (1999).

The attached affidavits of Rodney J. McCullum (Attachment 1), J.A. Stall (Attachment 2), Dhiaa M. Jamil (Attachment 3), David H. Jones (Attachment 4), Charles G. Pardee (Attachment 5), and Charles V. Sans Crainte (Attachment 6) discuss the particularized injuries suffered by NEI members as a result of the continuing lack of a licensed high level waste repository, and provide evidence from NEI members that demonstrate that NEI is authorized by members to petition to intervene and represent their interests in this matter. In general, NEI's members have standing to intervene based on their role and obligations as set forth in the NWPA and on their direct safety, security, environmental, operational, and financial interests in the timely licensing of the Yucca Mountain waste repository. As is discussed below and in the affidavits, these interests can be affected by the continuing unavailability of a repository, by the need for additional and ongoing onsite storage, and by the proposed design of the repository. Therefore, there are distinct harms, that are traceable to the licensing of the repository, that can be redressed by a favorable outcome in this proceeding.

For example, as discussed more fully in the affidavit of Mr. McCullum (Attachment 1), NEI members currently pay over $700 million per year in fees into the Nuclear

Waste Fund ("the Fund") established under the NWPA,[3] to cover all costs associated with used nuclear fuel disposal. Since its inception in 1983, NEI's members have paid a total of more than $16 billion into the Fund, and are obligated to substantial additional sums going forward.[4] NEI's members therefore have an interest in the timely licensing of the facility and in the appropriate use of monies from the Fund.

In addition, because of the ongoing lack of a licensed repository, used nuclear fuel remains in interim storage at the sites of both operating and permanently shut-down power reactors. As a result, nuclear reactor licensees have been compelled to increase spent fuel storage capacity at their sites by modifying the used fuel storage pools to increase the storage capacity of the pools and by constructing dry cask storage facilities. These projects involve substantial engineering and construction costs, as well as routine occupational radiation exposures. In addition, until used fuel is removed from the sites, current and former licensees continue to incur the operational challenges and costs, as well as the physical security requirements and occupational radiation exposures, associated with storage of used nuclear fuel. Removal of used fuel from the present interim storage locations to a licensed repository will also facilitate decommissioning of power reactor sites at the end of plant operation, expediting unrestricted release of the sites for future beneficial uses. And, to the extent NEI's contentions

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[3] 42 U.S.C. § 10222.

[4] As of September 30, 2007, NEI members had contributed $15,590,000,000 to the Fund. *See* Office of Civilian Radioactive Waste Management, Department of Energy, *Monthly Summary of Program Financial and Budget Information* (2007), http://www.ocrwm.doe.gov/about/budget/Monthly_Summary_September_2007.pdf.

herein assert that the DOE design is overly conservative, NEI members have an interest in both the timely licensing of the facility and a cost-effective project.[5]

All of these interests of NEI's members are germane — indeed central — to the mandate of NEI. NEI's members' interests are also well within the zones of interests of the AEA (radiological health, safety, and security associated with interim storage and disposal), NEPA (environmental impacts of interim storage and disposal), and the NWPA (timely and cost-effective development of the repository). Attachments 2 through 6 are affidavits that demonstrate that individual members authorize NEI to petition to intervene in this matter. Protection of the interests of NEI's members does not require the participation of individual members.[6]

Consistent with 10 C.F.R. § 2.309(a), NEI has represented its members and participated as a party in the NRC proceeding related to Yucca Mountain on pre-application matters. Additionally, NEI has participated in numerous rulemaking matters before the NRC and federal agencies (*e.g.*, the Environmental Protection Agency) on Yucca Mountain matters. NEI has also participated as a full-party intervenor in Yucca Mountain-related litigation in federal courts, including the consolidated challenges in the U.S. Court of Appeals, D.C. Circuit, to the federal standards for the repository embodied in 40 C.F.R. Part 191 and 10 C.F.R. Part 63. NEI's standing with respect to Yucca Mountain matters was specifically established in the Court

5 As is also discussed in the affidavit of Mr. McCullum, a recent report issued by the Electric Power Research Institute, *Occupational Risk Consequences of the Department of Energy's Approach to Repository Design, Performance Assessment and Operation in the Yucca Mountain License Application* (EPRI 2008), concludes that the over-design in certain respects of the proposed repository would result in unnecessary occupational risks and radiological exposures at the repository site.

6 In contrast, individual members' claims of damages caused by DOE's ongoing failure to meet its obligations under the NWPA are individually actionable by NEI's member companies.

of Appeals. *See Nuclear Energy Inst. Inc. v. Envtl. Protection Agency*, 373 F.3d 1251, 1278-79 (D.C. Cir. 2004), in which the Court of Appeals determined that, with respect to radiation safety standards for the nuclear waste repository, NEI had both judicial standing under Article III of the Constitution and prudential standing within the "zone of interests" created by the NWPA. The Court found judicial standing based on the fact that NEI members bear the primary cost for funding the Yucca Mountain facility through the Nuclear Waste Fund and will be adversely affected by a further delay of "the date on which the Energy Department will take stored waste off NEI members' hands." 373 F.3d at 1278. The Court found prudential standing based on the zone of interests created by the NWPA, because Congress clearly intended the NWPA to facilitate construction of a nuclear waste repository. *Id.* at 1280. Similarly, NEI has prudential standing to participate in this NRC licensing action. NEI's interest in the timely licensing and construction of the nuclear waste repository is well within the zone of interests created by the NWPA, as identified by the D.C. Circuit. *Id*. (discussing "Congress's intent to move the federal government expeditiously toward licensing and operating a repository at Yucca Mountain").[7]

NEI supports issuance of a license for the Yucca Mountain repository (modified only to the extent raised in NEI's specific proposed contentions below) and seeks to participate in this proceeding, as appropriate, on matters raised by other parties that oppose either the project or aspects of the project. The NRC's Appeal Board has previously addressed participation as of right by a petitioner favoring a licensing action of another party, and concluded that support for an application does not preclude standing. The Appeal Board stated:

> Standing to intervene hinges neither upon the litigating posture the petitioner would assume if allowed to participate nor on the merits of its case. *Association of Data Processing Service Organizations v. Camp*, 397

[7] As discussed in the affidavits, the interests of NEI's members are also within the zones of interests created b the AEA and NEPA.

> U.S. 1050, 153 (1970). Rather, the test is whether a cognizable interest of the petitioner might be adversely affected if the proceeding has one outcome rather than another.

Nuclear Engineering Co. (Sheffield, Illinois Low-Level Radioactive Waste Disposal Site), ALAB-473, 7 NRC 737, 743 (1978). More recently, the Licensing Board cited this precedent to allow participation by the Skull Valley Band of the Goshute Indians, who supported the license, in the proceeding related to a proposed commercial used fuel storage facility. *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), LBP-98-7, 47 NRC 142, 172 (1998). Accordingly, based on its support for the license and other considerations described above, NEI has standing as of right to participate in this proceeding.

B. Discretionary Standing

As discussed above, NEI meets the requirements for standing as of right in this proceeding. However, even if it did not, the NRC allows discretionary intervention in accordance with 10 C.F.R. § 2.309(e) and longstanding precedent. *See, e.g., Portland Gen. Elec. Co.* (Pebble Springs Nuclear Plant, Units 1 and 2), CLI-76-27, 4 NRC 610, 616 (1976).[8] In accordance with 10 C.F.R. § 2.309(e)(1), the following factors support NEI's participation in this matter:

(i) NEI's participation will assist in developing a sound record in the areas where NEI seeks to participate. NEI will provide direct, substantive expertise on these issues drawn from NEI staff, the staffs of its members' organizations, and NEI contractors who are leading international experts on repository safety and independent of the Yucca Mountain project.

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8 The concept of discretionary intervention is premised on the principle that federal agencies are not bound by judicial concepts of standing derived from Article III of the Constitution. *See Envirocare of Utah, Inc. v. Nuclear Regulatory Commission*, 194 F.3d 72,74 (D.C. Cir. 1999); *Sequoyah Fuels Corp. & Gen. Atomics* (Gore, Oklahoma Site), CLI-01-2, 53 NRC 9, 14 n.1 (2001).

(ii) NEI's members have a direct and substantial interest in this proceeding, as described above. Used fuel storage and disposal are important operational, safety, and financial issues for nuclear operators and former operators. In addition, removal of used fuel from the present interim storage locations will facilitate decommissioning of power reactor sites at the end of plant operation, expediting unrestricted release of the sites for future beneficial uses. NEI's members also have a direct interest in the prudent use of expenditures from the Nuclear Waste Fund.

(iii) Any decision or order that may be issued in this proceeding (whether favorable or adverse) will directly impact NEI's members.

The factors potentially weighing against allowing intervention, as outlined in 10 C.F.R. § 2.309(e)(2), have little or no weight here:

(i) NEI and its members do not have another means or forum in which to address their interest in the NRC licensing of the proposed high level waste repository. The NRC is the sole forum in which these issues will be directly addressed.

(ii) NEI's interests will not be adequately addressed by other parties. No party other than DOE will support the project and demonstrate its acceptability with the same vigor and technical expertise as would NEI. Moreover, NEI's interests and DOE's interests are not identical or co-terminus.

(iii) NEI's participation will not significantly broaden the scope of this proceeding or delay licensing of the project. Undoubtedly, this proceeding will be a significant undertaking in scope and depth of issues. NEI clearly has no interest in delay and will be motivated to expedite the proceeding.

In total, NEI clearly has an interest and the ability to support discretionary intervention. This conclusion is further supported by NEI's longstanding participation, as described above, in NRC pre-application matters, NRC rulemaking matters, and federal judicial matters related to Yucca Mountain.

III. NEI'S SPECIFIC CONTENTIONS

NEI - SAFETY - 01: Spent Nuclear Fuel Direct Disposal in Dual Purpose Canisters

Contention [10 C.F.R. 2.309(f)(1)(i)]: The License Application ("LA") fails to permit direct disposal of dual purpose canisters ("DPCs") containing commercial spent nuclear fuel and is therefore inconsistent with "as low as is reasonably achievable" ("ALARA") principles, unnecessarily generates additional low-level radioactive waste ("LLRW"), and wastes limited resources.

Basis [10 C.F.R. 2.309(f)(1)(ii)]: The technical basis for proposed Contention NEI-SAFETY-01 is set forth in detail in an affidavit from qualified experts, Dr. Matthew W. Kozak, Brian Gutherman, and Richard A. Loftin (included with the NEI Petition at Attachment 7), who explain that the LA states that all commercial spent nuclear fuel ("SNF") will be loaded into Transportation, Aging, and Disposal ("TAD") canisters for disposal, which means that SNF loaded into DPCs will need to be unloaded and then reloaded into TAD canisters prior to disposal, whether that unloading and reloading occur at Yucca Mountain or at reactor sites. The number of DPCs that would have to be unloaded and then reloaded ranges from at least 1,029 to 2,155 DPCs by the time Yucca Mountain is scheduled to open in 2020. Because the SNF-filled DPCs can be directly disposed while meeting the requirements of 10 C.F.R. Part 63, workers (whether at Yucca Mountain or reactor sites) will be unnecessarily exposed to increased radiation as a result of unloading and reloading these DPCs. In addition, the discarded DPCs will be unnecessary LLRW, and the unloading and reloading processes will result in increased resource use and costs.

Scope of Proceeding [10 C.F.R. 2.309(f)(1)(iii)]: The issue raised in this contention is within the scope of this proceeding as it relates to the Nuclear Regulatory Commission's ("NRC's" or "Commission's") Atomic Energy Act ("AEA") and Nuclear Waste Policy Act ("NWPA") responsibilities. As discussed below, it raises an issue that is material to the findings that the NRC must make to support issuance of a license.

Materiality [10 C.F.R. 2.309(f)(1)(iv)]: 10 C.F.R. § 50.40 and 10 C.F.R. § 63.111 provide, respectively, that (1) reactor licensees and (2) the geologic repository operations area must meet the requirements of 10 C.F.R. Part 20. 10 C.F.R. § 20.1002 states that Part 20 applies to persons holding NRC licenses under 10 C.F.R. Part 50 and 10 C.F.R. Part 63. 10 C.F.R. § 20.1101(b) states that "licensee[s] shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are [ALARA]," and 10 C.F.R. § 20.1003 defines "ALARA" as "making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest." Here, the LA's failure to permit direct disposal of commercial SNF contained in DPCs is not consistent with ALARA principles because the unloading and reloading of spent fuel from DPCs into TAD canisters will result in (1) unnecessary radiation exposures to reactor and repository site workers; (2) the unnecessary generation of low-level radioactive waste ("LLRW"); and (3) increased resource use and costs. The radiation exposure, LLRW generation, and increased resource use and costs are unnecessary because DPCs can be directly disposed in the repository while still meeting the requirements of Part 63.

Facts, Opinions, and References [10 C.F.R. 2.309(f)(1)(v)]: NEI's contention that the LA's failure to permit direct disposal of SNF in DPCs is inconsistent with ALARA principles is based on the following facts and opinions, as set forth in detail in the affidavit of Dr. Kozak, and Messrs. Gutherman, and Loftin:

a. As proposed, the LA requires that all commercial SNF be loaded into TAD canisters prior to disposal in the Yucca Mountain repository. *See* Kozak, Gutherman, and Loftin Affidavit at ¶¶ 29-32.

b. At least 1,029 DPCs – and potentially as many as 2,155 DPCs if DOE does not make TAD canisters commercially available in 2013 or later – will be loaded with commercial spent nuclear fuel at reactor sites by the time Yucca Mountain is expected to open. *Id.* at ¶¶ 42-44.

c. Thus, under DOE's proposed action, all commercial SNF stored in DPCs would have to be unloaded from those DPCs and reloaded into TAD canisters, either at reactor sites or at the repository. The unloading and reloading processes will cause reactor site workers and/or repository site workers to incur radiation dose – approximately 822 person-rem for unloading SNF from the 1,029 DPCs estimated to be in existence by the time Yucca Mountain is expected to open in 2020, and for reloading that SNF into TADs. *Id.* at ¶¶ 49-53.

d. The unloaded and discarded DPCs will create a stream of LLRW, which would require processing, handling, and disposal or recycling, and which are likely to cause additional radiation dose to be incurred. *Id.* at ¶ 54.

e. The unloading and reloading processes, and the processing, handling, and disposal or recycling of the discarded DPCs, will require resources that could be put to other uses. The money invested in DPCs would be lost because the DPCs will have to be discarded. *Id.* at ¶ 55.

f. The increase in incurred radiation doses, LLRW generated, and anticipated resource use and costs are unnecessary because DPCs can be directly disposed in the repository. There would be no significant effects on repository pre-closure performance or post-closure performance if DPCs were directly disposed. The proposed repository would meet all performance requirements if DPCs were directly disposed of in the repository. *Id.* at ¶¶ 56-70.

g. Therefore, DOE's proposed action is not consistent with ALARA principles because it would result in increased radiation doses, generation of LLRW, and increased costs and use of resources, all of which are unnecessary results because DOE could avoid these results by directly disposing of DPCs. *Id.* at ¶ 71.

Genuine Dispute [10 C.F.R. 2.309(f)(1)(vi)]: LA Safety Analysis Report ("SAR") Sections 1.5, 1.5.1, and 1.5.1.1 state that any commercial SNF that arrives at the repository in DPCs will be unloaded from the DPCs and reloaded into TAD canisters prior to disposal. LA SAR Section 1.5.1.1.1.2.1.2 states that DPCs have not been demonstrated as suitable for direct disposal. NEI disputes these provisions and the need for SNF to be reloaded into TAD canisters. As discussed above, the unloading and reloading processes result in consequences that would be avoided were DOE to directly dispose of DPCs. DPCs can be directly disposed of in the repository while meeting the repository's performance requirements.

Joint Sponsors: None.

NEI - SAFETY - 02: Insufficient Number of Non-TAD SNF Shipments to Yucca Mountain

Contention [10 C.F.R. 2.309(f)(1)(i)]: Yucca Mountain's surface facility design capability to receive not less than 90% of commercial spent nuclear fuel ("SNF") in Transportation, Aging, and Disposal ("TAD") canisters is inconsistent with "as low as is reasonably achievable" ("ALARA") principles.

Basis [10 C.F.R. 2.309(f)(1)(ii)]: The technical basis for proposed Contention NEI-SAFETY-02 is set forth in detail in an affidavit from qualified experts Brian Gutherman and Richard A. Loftin (included with the NEI Petition at Attachment 8), who explain: the Yucca Mountain License Application ("LA") states that the repository surface facilities are designed to receive at least 90% of commercial spent nuclear fuel at the repository in TAD canisters (loaded at reactor sites). This will result in some commercial SNF already loaded into dual-purpose canisters ("DPCs") and transportable bare fuel casks ("BFCs") being unloaded and reloaded into TAD canisters at reactor sites instead of at the repository. This in turn will result in reactor site workers responsible for unloading the DPCs and BFCs and reloading the spent nuclear fuel into TAD canisters for transport being unnecessarily exposed to increased radiation dose, a result that can be reduced if DOE accepts up to 25% of commercial spent nuclear fuel in DPCs and transportable BFCs. DOE has analyzed the environmental impacts of an alternative scenario whereby up to 25% of SNF would be received at Yucca Mountain in non-TAD canisters and casks and concluded that there would be little if any additional environmental impacts at the repository under this scenario.

Scope of Proceeding [10 C.F.R. 2.309(f)(1)(iii)]: The issue raised in this contention is within the scope of this proceeding as it relates to the Nuclear Regulatory Commission's ("NRC's" or "Commission's") Atomic Energy Act ("AEA") and Nuclear Waste Policy Act ("NWPA") responsibilities. As discussed below, it raises an issue that is material to the findings that the NRC must make to support issuance of a license.

Materiality [10 C.F.R. 2.309(f)(1)(iv)]: 10 C.F.R. § 50.40 and 10 C.F.R. § 63.111 provide, respectively that (1) reactor licensees and (2) the geologic repository operations area must meet the requirements of 10 C.F.R. Part 20. 10 C.F.R. § 20.1002 states that Part 20 applies to persons holding NRC licenses under 10 C.F.R. Part 50 and 10 C.F.R. Part 63. 10 C.F.R. § 20.1101(b) states that "licensee[s] shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA)," and 10 C.F.R. § 20.1003 defines "ALARA" as "making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest." Here, the Yucca Mountain surface facility design capability that receives not less than 90% of commercial SNF in TAD canisters is inconsistent with ALARA principles. By the time Yucca Mountain is expected to open in 2020, even assuming industry begins loading commercial SNF into TADs in 2013, far more than 10% of commercial SNF will be stored in non-TAD canisters that will be able to be transported to Yucca Mountain. Repackaging the SNF at the repository for disposal will result in less radiological exposure and will not result in any additional significant environmental impacts.

Facts, Opinions, and References [10 C.F.R. 2.309(f)(1)(v)]: NEI's contention that Yucca Mountain's surface facility design capability to receive not less than 90% of commercial SNF in TAD canisters is inconsistent with ALARA principles is based on the following facts and opinions, as set forth in detail in the affidavit of Messrs. Gutherman and Loftin:

a. As proposed, the LA requires that all commercial SNF to be disposed of in the Yucca Mountain repository – 63,000 metric tons of heavy metal ("MTHM") – be loaded into TAD canisters prior to disposal. *See* Gutherman and Loftin Affidavit at ¶¶ 20-21, 24.

b. DOE has designed the repository surface facilities to receive at least 90% of commercial SNF in TAD canisters, but only up to 10% of commercial SNF (6,300 MTHM) in transportable canisters and casks. *Id.* at ¶ 25.

c. By the time Yucca Mountain is expected to open in 2020, at least 14,354 MTHM of U.S. commercial SNF will reside in transport-licensed DPCs and BFCs, which exceeds the 10% allotment for non-TAD SNF by (at least) 8,054 MTHM. *Id.* at ¶¶ 33-36.

d. DOE has analyzed an alternative scenario where it would receive up to 25% of commercial SNF (15,750 MTHM of the 63,000 MTHM total) in non-TAD canisters and casks. DOE concluded that no additional significant environmental impacts would result under this scenario. *Id.* at ¶¶ 37-39.

e. Repackaging commercial SNF from transportable canisters and casks to TADs at the repository will incur less radiological dose than if the repackaging occurs at reactor sites because of (1) more efficient operations at the repository, and (2) workers who perform repackaging operations regularly at the repository. *Id.* at ¶¶ 44-46.

f. Thus, the proposed Yucca Mountain repository's surface facility design capability that receives not less than 90% of commercial SNF in TAD canisters is inconsistent with ALARA principles. *Id.* at ¶ 48.

Genuine Dispute [10 C.F.R. 2.309(f)(1)(vi)]: LA General Information Section 1.2.2 states that the surface facilities have been designed to support a mostly canisterized waste stream, and that the repository objective is to have 90% of individual commercial SNF assemblies loaded into TAD canisters by the utilities, with the remaining quantity of SNF arriving at the repository in DPCs or transportation casks. LA SAR Section 1.5.1.1 states that the repository shall be capable of accepting, transporting, and disposing of commercial SNF where at least 90% is received in TAD canisters and no more than 10% is received in DPCs or bare fuel casks. NEI disputes these provisions – specifically, the surface facility design capability to receive no more than 10% of commercial SNF in non-TAD canisters. More than 10% of commercial SNF will be stored in non-TAD canisters at reactor sites by the time Yucca Mountain opens in 2020. Thus, under DOE's proposal, much of that SNF will have to be repackaged into TADs at reactor sites. However, repackaging into TAD canisters at reactor sites will result in greater radiological dose than if repackaging occurred at the repository. Accordingly, DOE's proposed action is not consistent with ALARA principles.

Joint Sponsors: None.

NEI - SAFETY - 03: Excessive Seismic Design of Aging Facility

Contention [10 C.F.R. 2.309(f)(1)(i)]: The design requirement stated in Section 1.2.7.1.3.2.1 of the License Application (LA) Safety Analysis Report (SAR) specifying that the vertical aging overpack system "must withstand a seismic event characterized by horizontal and vertical peak ground accelerations of 96.52 ft/s^2 (3g) without tipover and without exceeding canister leakage rates" is excessively conservative, goes beyond the necessary safety margin, and is not consistent with ALARA principles.

Basis [10 C.F.R. 2.309(f)(1)(ii)]: The technical basis for proposed Contention NEI-SAFETY-03 is set forth in detail in two affidavits from qualified experts: (1) the affidavit of Christopher W. Fuller, Ph.D., Michael G. Gray, M.S., P.G., C.E.G., and Daniel R.H. O'Connell, Ph.D. (included with the NEI Petition at Attachment 9); and (2) the affidavit of Brian Gutherman (Attachment 10). NEI's experts explain that Section 1.2.7.1.3.2.1 of the LA SAR establishes a design requirement for the vertical aging overpack system by which the system must be able to withstand a seismic event characterized by horizontal and vertical peak ground accelerations of 96.52 ft./s^2 (3g) without tipover and without exceeding canister leakage rates. NEI's experts contend that this 3g design requirement is excessively conservative and inappropriate. This excessive design requirement could increase licensing uncertainty and delay, and could increase the occupational exposures associated with the facility.

Scope of Proceeding [10 C.F.R. 2.309(f)(1)(iii)]: The issue raised in this contention is within the scope of this proceeding. As discussed below, it raises an issue that is material to the findings that the NRC must make to support issuance of a license.

Materiality [10 C.F.R. 2.309(f)(1)(iv)]: The seismic design of the vertical aging overpack system is directly addressed in LA SAR Section 1.2.7.1.3.2.1, and is material to the preclosure safety analysis required by 10 C.F.R. 63.112 (*see, e.g.*, 10 C.F.R. 63.112(e)(8)) and to DOE's demonstration that the performance objectives of 10 C.F.R. 63.111 have been met. The excessive conservatism of the proposed design standard for the aging overpack system goes beyond the necessary margin of safety (contrary to any arguments of other petitioners that may be directed to the adequacy of the aging overpack system). The overly conservative design unnecessarily increases licensing uncertainty and risk of delay.

Moreover, the conservative DOE approach may lead to unnecessary occupational doses at the operational repository. 10 C.F.R. § 63.111(a)(1) provides that the repository operations area must meet the requirements of 10 C.F.R. Part 20. 10 C.F.R. § 20.1002 provides that Part 20 applies to persons holding NRC licenses under 10 C.F.R. Part 50 and 10 C.F.R. Part 63. Section 20.1101(b) requires that licensees use, to the extent practical, procedures and engineering controls to achieve occupational doses that are as low as is reasonably achievable (ALARA). The 3g design requirement is not consistent with ALARA principles, which are further defined in 10 C.F.R. § 20.1003.

Facts, Opinions, and References [10 C.F.R. 2.309(f)(1)(v)]: NEI's contention that the 3g design requirement for the vertical aging overpack system is excessively conservative and inappropriate is based on the following facts and opinions (and references), as set forth in detail in the affidavit of Dr. Fuller, Mr. Gray, and Dr. O'Connell. NEI's experts have interpreted DOE's derivation of the 3g design requirement from two 2008 DOE reports addressing the Transportation, Aging and Disposal (TAD) canister system performance specification and rationale, and state the following:

a. There is no risk-informed basis provided by DOE for the design basis corresponding to a 3g ground motion at the surface facilities. In fact, the design basis requirement is significantly more conservative than the design bases used for comparable nuclear facilities regulated by the NRC. Specifically, seismic hazard curves in the LA SAR show that the 3g ground motion corresponds to a mean annual probability of exceedence (MAPE) of approximately $9x10^{-7}$ and $4x10^{-7}$, for horizontal and vertical peak ground acceleration (PGA), respectively. These MAPEs are substantially lower than the MAPEs utilized for power reactors and fuel storage facilities, as stated in a 2007 DOE report. A design basis ground motion with a MAPE between that of a fuel storage facility (*i.e.*, $4x10^{-4}$ to $5x10^{-4}$) and a nuclear power plant (*i.e.*, $1x10^{-4}$ to $1x10^{-5}$) would be more reasonable for the aging overpack system. *See* Fuller, Gray, O'Connell Affidavit at ¶¶ 6-11

b. The probabilistic seismic hazard analysis (PSHA) used by DOE to derive the 3g design requirement (at a MAPE of $2x10^{-6}$ or lower) overestimates PGA for the aging pads due to unnecessary, incorrect, and/or overly conservative assumptions. *Id*. at ¶12. There are five issues that NEI's experts contend are inappropriate assumptions. The five issues relate to two components of the PSHA model: (1) the equations describing the attenuation of strong ground motions; and (2) the site response calculations.

Attenuation Issues

1. Uncertainties in the ground motion equations led to unrealistically large predicted ground motions in the PSHA at low annual frequencies of exceedences (AFE). The experts relied upon in the expert elicitation process did not evaluate appropriate limits for the uncertainty distributions at low AFEs and large epsilons. This resulted in ground motions that have

been recognized by many experts to be physically unreasonable. *Id*. at ¶¶ 15-17.

2. Last-minute, un-reviewed changes in the attenuation relationship in the ground motion equation, made by one expert during the DOE expert elicitation process, were overly conservative and have led to excessive ground motion estimates. The expert believed that un-toppled, precariously balanced rocks provide evidence that ground motions were not capable of reaching levels predicted by the equations. Therefore, he increased his estimate of epistemic uncertainty and applied a symmetric distribution. However, a more appropriate use of an asymmetric distribution of epistemic uncertainty, rather than a symmetric distribution, would be consistent with the evidence of precariously balanced rocks referred to by the expert and would likely result in a PGA significantly lower than 3g. *Id*. at ¶¶ 18-20.

3. Estimates of epistemic uncertainty are excessively conservative due to use of a natural-log standard deviation for mean PGA that increases with increasing magnitude, which contradicts empirical data. *Id*. at ¶ 21.

4. The attenuation equations used for Yucca Mountain are overly conservative relative to more recent knowledge embodied in the Next Generation Attenuation equations released in 2006 and finalized in 2008. *Id*. at ¶ 22.

Site Response Issue

5. A single, enveloping soil-response ground motion was developed for all surface facilities that is overly conservative for the observed site conditions and expected soil amplification beneath the aging pads. *Id*. at ¶¶ 23-25.

NEI's contention that the overly conservative design of the aging facility is inconsistent with ALARA principles is explained in the affidavit of Mr. Gutherman. Depending on the design ultimately adopted for that system, additional time may be required for installation of the system (*e.g.*, installing a structural restraining system or other apparatus), thereby increasing occupational doses to workers. *See* Gutherman Affidavit, at ¶¶ 8-10.

Additional references are set forth in the affidavit of Dr. Fuller, Mr. Gray, and Dr. O'Connell.

Genuine Dispute [10 C.F.R. 2.309(f)(1)(vi)]: Section 1.2.7.1.3.2.1 of the LA SAR states that the vertical aging overpack system of the aging facility "must withstand a seismic event characterized by horizontal and vertical peak ground accelerations of 96.52 ft/s^2 (3g) without tipover and without exceeding canister leakage rates." NEI disputes this section of the SAR and the need for this 3g design requirement.

As noted above, NEI's experts contend that the 3g design requirement is excessively conservative because: (1) the design basis corresponding to a 3g ground motion at the surface facilities is significantly more conservative than the design bases used for comparable nuclear facilities regulated by the NRC; and (2) the seismic hazard curve used by DOE to derive the 3g design requirement overestimates the PGA for the aging pads on which the aging overpacks will be positioned due to excessive conservatisms within the PSHA.

Based on interpreting DOE's derivation of the 3g design requirement, NEI's experts further conclude that the design requirement was added to the TAD canister specifications because DOE believes that 3g horizontal and vertical PGA is a “credible” ground motion at the aging pads. NEI disputes this rationale.

Joint Sponsors: None.

NEI - SAFETY - 04: Low Igneous Event Impact on TSPA

Contention [10 C.F.R. 2.309(f)(1)(i)]: The Department of Energy (DOE) in the License Application (LA) has modeled the scenario of a volcano at the Yucca Mountain site in the Total System Performance Assessment (TSPA). Based on an unreasonable set of assumptions that postulate the complete failure of every waste package in the repository, DOE conservatively concludes that intrusive igneous events that intersect the repository account for approximately 40% of the total dose over a 10,000 year period. Based on an analysis and calculation by the Electric Power Research Institute (EPRI), DOE has been excessively conservative in its treatment in the LA TSPA of the consequences of a potential igneous event. NEI contends that in fact substantial additional safety margin exists in this area. NEI contends that if DOE considered a reasonably expected intrusive igneous scenario, the related consequences would show no significant release of radionuclides. DOE's conservative treatment and results could contribute to licensing uncertainty and could delay the development of the repository.

Basis [10 C.F.R. 2.309(f)(1)(ii)]: The technical basis for this contention is set forth in detail in the affidavit of NEI's qualified experts, Michael J. Apted, Ph.D., and Meghan M. Morrissey, Ph.D. (included with the NEI Petition at Attachment 11), drawing on several relevant EPRI reports (2004; 2005; 2007; 2008), in which they were involved. NEI's experts also reference a final report (2007) of the Advisory Committee on Nuclear Waste (ACNW) on the viscosity of magma in the Yucca Mountain Region.

NEI's experts explain that Section 2.3.11 (at 2.3-1) of the LA Safety Analysis Report (SAR) states that "future igneous activity at the site (repository) is included in the features, events and processes (FEPs) that are incorporated in the TSPA-LA for the repository because [of] the mean annual probability of intersection of the repository by an igneous event.…" The TSPA-LA model and repository assessment analysis described in the SAR (Section 2.4.1.1) "follow the requirements in proposed 10 CFR 63.342(c) by projecting the continued effects of the 10,000 year screened-in FEPs through the period of geologic stability (up to 1,000,000 years after permanent closure), and including the effects of seismic events, igneous events, climate change and general corrosion beyond 10,000 years." As stated in Section 2.4.1.2 (at 2.4-11), the TSPA-LA calculation in the SAR "calculates the total annual dose as the sum of the annual doses attributed to the nominal scenario class, the early failure class and the two disruptive event scenario classes (igneous scenario class and seismic scenario class)." DOE notes in Section 2.4.2.2.1.1.2 (at 2.4-57) of the LA SAR that the mean annual doses calculated for the igneous intrusive modeling case are one of the two dominant contributors to the total dose; "all other modeling cases for both the 10,000 year and post-10,000 year time periods comprise on the order of 1% or less of the total mean annual dose."

NEI's experts contend, drawing on the EPRI analysis and other work, that the TSPA-LA estimate of the contribution to mean annual dose attributed to the igneous scenario class is excessively conservative because the basic assumptions in DOE's igneous intrusive modeling case regarding magma behavior and waste package failure are unreasonably pessimistic. NEI contends that only a portion of the emplacement drifts would be intersected by a dike, and that inside those few intersected emplacement drifts magma would flow only a limited distance before cooling and solidifying due to heat losses to the tuff wall rock and massive engineered barriers within the drifts. Therefore, any potential future magmatic intrusion would only contact a small number of waste packages in a repository at Yucca Mountain. Additionally, factors related to the interactions between the magma and waste packages and the properties of the spent fuel would tend to mitigate and reduce release and transport of radiological materials. Each of these factors of the analysis is discussed in more detail in the supporting affidavit.

Scope of Proceeding [10 C.F.R. 2.309(f)(1)(iii)]: The issue raised in this contention is within the scope of this proceeding. As discussed below, it raises an issue addressed in the LA SAR and the TSPA-LA, and that is material to the findings that the NRC must make to support issuance of a license.

Materiality [10 C.F.R. 2.309(f)(1)(iv)]: The consequences of volcanism at the Yucca Mountain site is directly addressed in SAR Section 2.4.2.3 and is material to the post-closure performance assessment required by 10 C.F.R. 63.114 and the performance objectives specified by 10 C.F.R. 63.113 and 63.311 (*see*, *e.g.*, 10 C.F.R. 63.113(b)("the engineered barrier system must be designed so that, working in combination with natural barriers, radiological exposures to the reasonably maximally exposed individual are within the limits specified at 63.311 of subpart L of this part")). DOE's analysis of consequences of an igneous event is also directed to the requirements in proposed 10 CFR 63.342(c)[9] by projecting the continued effects of the 10,000 year screened-in FEPs through the period of geologic stability (up to 1,000,000 years after permanent closure), and including the effects of seismic events, igneous events, climate change and general corrosion beyond 10,000 years. Furthermore, 10CFR 63.311 as proposed directs that DOE demonstrate, using performance assessment, that there is a reasonable expectation that, for 10,000 years following disposal the "reasonably maximally exposed individual" receives no more than an annual dose of 15 millirem per year. DOE's analysis is more conservative than a "reasonable expectation" and leads to a perception of reduced licensing margin. Reduced margin will complicate the licensing review and could lead to licensing delay. Licensing delay will increase the period of fuel storage at existing reactor and fuel storage sites, resulting in ongoing

[9] *See* SECY-08-0170, "Final Rule: 10 CFR Part 63, 'Implementation of a Dose Standard After 10,000 Years' (RIN 3150-AH68), November 4, 2008.

operational complexity, occupational exposures, and economic and environmental costs associated with interim used fuel storage.

Facts, Opinions, and References [10 C.F.R. 2.309(f)(1)(v)]: As stated in the LA SAR (Section 2.3.11.3.2.4, at 2.3.11-32), "for TSPA, it is assumed that (1) following intersection of the repository, all drifts are rapidly filled with magma; (2) all waste packages in drifts are engulfed in magma; and (3) the waste packages contacted by magma are damaged and fail, providing no protection for the waste from groundwater (SNL 2007b, Section 5.1)." DOE goes on to state (Section 2.3.11.3.2.3**,** at 2.3.11-32**)** that "[f]or the purposes of TSPA, the details of these processes are simplified such that all waste packages that are contacted by magma are assumed to fail in terms of their ability to contain spent fuel (SNL 2007b, Section 5.1)."

As set forth in more detail in the affidavit of Dr. Apted and Dr. Morrissey, NEI contends that, based on work done on behalf of EPRI, DOE's assumptions are overly simplified and overly conservative. EPRI has based its conclusions on a conceptual model specifically developed for an igneous event in the Yucca Mountain region. EPRI's model is based on a comprehensive assessment of geological, geochemical, and geophysical data from DOE, other agencies, and academic institutions. In total, in the unlikely event that an igneous intrusive event were to occur in the Yucca Mountain region, EPRI's series of reports demonstrate that only a small number (<10) of waste packages may come in direct contact with a gas depleted magma, and that any failure of these waste packages would result in a significantly lower radiological releases (or doses) than estimated by DOE in its TSPA-LA.

NEI's contention is based on the following facts and opinions (and references), as set forth in more detail in the Affidavit of Dr. Apted and Dr. Morrissey:

a. DOE states in Section 2.4.2.3.2.1.12.2 (at 2.4-193), that the "flow characteristics of the intruding magma are assumed to be such that it fills every drift within the repository". Furthermore, DOE states that their model (Section 2.3.11.3.2.7, at 2.3.11-34) "assumes that all drifts in the repository are filled with magma if any drift (including access and exhaust drifts) in the repository is intersected (SNL 2007a, Section 5.1). Because all drifts are assumed to be filled with magma following an igneous intrusion, all waste packages [11,692 waste packages] in the repository are contacted by magma." These assumptions by DOE are excessively pessimistic. NEI's experts conclude that a more reasonable model would consider realistic viscosities that reflect the nature of magma expected in the Yucca Mountain region, and heat transfer mechanisms expected in the drift (such as the thermal diffusivity of the waste packages and engineered barriers). A more reasonable assumption would be that the rising magma would intersect only a portion of the drifts, and would travel only some partial distance down an intersected drift before cooling and solidifying. Therefore, the magma would not fill the entire repository and engulf all waste packages. *See* Apted, Morrissey Affidavit at ¶ 7.

1. EPRI estimates that the number of drifts intersected would be between 5 and 41. This range is consistent with DOE's own pre-LA estimate in 2003. *Id.* at ¶ 10.

2. EPRI's conceptual model specifically differs from DOE's with respect to the expected behavior of magma inside a drift. DOE assumes a viscosity based on studies of Hawaiite basalts. These basalts are very different from

basalts from the Yucca Mountain region. EPRI's analyses use the appropriate basalts and incorporate a lower temperature and higher viscosity. As a result, NEI's experts conclude that magma will flow only partially into emplacement drifts and will thereby impact only a limited number of waste packages. *Id.* at ¶¶ 11-12. The Advisory Committee on Nuclear Waste (ACNW), an independent, scientific advisory panel to the NRC, has also cited recent work that demonstrates that magma viscosities expected for a future igneous event at Yucca Mountain would be several orders of magnitude greater than assumed by DOE, which would reduce the rate of magma entry into drifts. *Id.* at ¶ 13.

3. NEI's experts conclude that DOE has also inappropriately ignored heat transfer mechanisms expected in the drift (such as the thermal diffusivity of the waste packages and engineered barriers). DOE assumes that the rate of cooling of magma in the drift depends mainly on the rate of the thermal diffusivity of the welded tuff and the basalt, which are assumed to be the same. The presence of waste packages and engineered barriers are considered in DOE's analysis of magma cooling and are assumed to have similar thermo-mechanical properties as the wall rock and basalt. The thermo-mechanical properties of a waste package such as conductivity are actually roughly one order of magnitude greater than basalt or welded tuff. *Id.* at ¶ 14.

b. The EPRI analysis discussed by NEI's experts also specifically considers magma-waste package interactions potentially mitigating radionuclide releases in the event of magma intrusion into the emplacement drifts. These interactions may vary according to “zones.” Interactions can include (but are not limited to): a) encasement of waste packages by solidified basalt that would provide a transport constraint on radionuclides; b) insufficient temperature-time conditions to lead to loss of containment by the Alloy-22 outer barrier of the waste package; c) contact by reactive volatiles from the degassing magma that is not sufficient to cause waste package failure. *Id.* at ¶¶ 16-19.

c. An additional factor that would tend to mitigate the consequences of an igneous intrusive event is the mechanical and chemical durability of spent fuel pellets and cladding. According to ACNW, entrained radionuclides from failed waste packages during an eruption event would be likely to remain in relatively large fragments that would be deposited in or near a tephra cone, rather than as far-strewn, fine-grained ash. This result suggests that the spent fuel would remain largely intact if such an event were to occur. *Id.* at ¶ 20.

d. EPRI has combined the waste package-magma interactions, including the partial penetration of gas depleted magma inside a drift, into a series of dose calculations to evaluate the igneous-intrusive scenario. Even for extremely pessimistic assumptions about the cumulative probability of an intrusive igneous event, the EPRI study calculated a mean dose peak below 0.1 millirem/y when considering the various mitigating effects of waste package-magma interactions. This calculated dose rate is substantially less than the DOE estimate and more than two orders of magnitude less than the draft EPA regulatory limit. *Id.* at ¶ 21.

Additional references are set forth in the affidavit of Dr. Apted and Dr. Morrissey.

Genuine Dispute [10 C.F.R. 2.309(f)(1)(vi)]: As discussed above, Sections 2.3 and 2.4 of the LA SAR specifically discuss the potential for future igneous activity at the Yucca Mountain site, and DOE has specifically modeled the scenario in the TSPA-LA. DOE concludes that igneous events that intersect the repository account for approximately 40% of the total dose over a 10,000 year period. NEI disputes this assessment. NEI's experts contend that the assessment is based on overly conservative assumptions regarding magma behavior and the number of waste packages impacted. NEI's experts further contend that the assessment fails to consider realistic constraints on magma-waste package interactions, and other factors, that would limit radionuclide releases. As a result, there is a genuine dispute regarding the contribution of postulated igneous activity to the calculated 10,000 year dose.

Joint Sponsors: None.

NEI - SAFETY - 05: Excessive Conservatism in the Postclosure Criticality Analysis

Contention [10 C.F.R. 2.309(f)(1)(i)]: The postclosure criticality analysis described in Section 2.2.1.4.1.1 of the License Application (LA) Safety Analysis Report (SAR) provides a substantial safety margin, is excessively conservative, and will unnecessarily lead to the expectation that disposal control rod assemblies be inserted in some fuel assemblies at nuclear power plants prior to shipment to disposal.

Basis [10 C.F.R. 2.309(f)(1)(ii)]: The technical basis for this contention is set forth in detail in the affidavit of NEI's qualified expert, Everett L. Redmond II, Ph.D (included with the NEI Petition at Attachment 12). NEI's expert explains that Section 2.2.1.4.1.1 of the LA Safety Analysis Report describes the postclosure criticality analysis which is excessively conservative in several respects and inconsistent with common industry practice. This overly conservative design will result in installation of disposal control rod assemblies at nuclear power plants in some cases, creating increased occupational dose to workers, unnecessary expenditures from the Nuclear Waste Fund, and increased economic and environmental costs.

Scope of Proceeding [10 C.F.R. 2.309(f)(1)(iii)]: The issue raised in this contention is within the scope of this proceeding. As discussed below, it raises an issue that is material to the findings that the NRC must make to support issuance of a license.

Materiality [10 C.F.R. 2.309(f)(1)(iv)]: The postclosure criticality analysis is directly addressed in LA SAR Section 2.2.1.4.1.1, and is material to the postclosure safety analysis required by 10 C.F.R. 63.114 and to DOE's demonstration that the performance objectives of 10 C.F.R. 63.113 have been met. In addition, 10 C.F.R. § 50.40 and 10 C.F.R. § 63.111 provide, respectively, that (1) reactor licensees and (2) the geologic repository operations area must meet the requirements of 10 C.F.R. Part 20. 10 C.F.R. § 20.1002 provides that Part 20 applies to persons holding NRC licenses under 10 C.F.R. Part 50 and 10 C.F.R. Part 63. 10 C.F.R. § 20.1101(b) states that "licensee[s] shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are [ALARA]," and 10 C.F.R. § 20.1003 defines "ALARA" as "making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest."

The excessive conservatism of the postclosure criticality analysis goes well beyond what is appropriate or necessary to assure safety. Adherence to standard industry practice will provide a sufficient margin of safety.

Moreover, from the perspective of the nuclear industry, the overly conservative analysis unnecessarily increases licensing uncertainty and creates a de facto expectation that disposal control rod assemblies (Section 2.2.1.4.1.1.3) be inserted into some fuel assemblies at the nuclear power plants. That activity will result in increased occupational dose to the workers who must install these devices and is not consistent with the principles of ALARA. Eliminating the disposal control rod assemblies will also reduce the operational complexity, occupational exposures, and economic and environmental costs associated with dry storage and disposal of used nuclear fuel. Requiring disposal control rod assemblies as a result of the excessively conservative postclosure criticality analysis would also result in unnecessary design and operational costs to be paid from the Nuclear Waste Fund. Finally, the need for a new cask configuration could create additional impacts on the nuclear industry as a result of delays in licensing new Transportation, Aging and Disposal ("TAD") canister designs. Avoiding licensing delay will reduce the period of fuel storage at existing reactor and fuel storage sites.

Facts, Opinions, and References [10 C.F.R. 2.309(f)(1)(v)]: NEI's contention that the postclosure criticality analysis is overly conservative and inappropriate is based on the following facts and opinions (and references) as set forth in detail in the affidavit of Dr. Everett Redmond (Attachment 12). The post closure criticality analysis is excessively conservative in each of the following respects:

a. Assuming full flooding with water, without regard to the relevant probabilities, as discussed in Section 2.2.1.4.1.1.2.1,

b. Using 6 mm for the neutron absorber thickness in the TAD canister, which is unnecessarily conservative compared to the 9 mm predicted, as discussed in Section 2.2.1.4.1.1.2.2,

c. Taking credit for only 75% of the neutron absorber content, as discussed in Section 2.2.1.4.1.1.2.2, as compared to 90% credit which has been taken in other applications,

d. Calculating the isotopic compositions for a cooling time of 5 years, as discussed in Section 2.2.1.4.1.1.2.2, rather than a more realistic number based on the expected age of the fuel and the length of the pre-closure period,

e. Developing and using a calculational adjustment (bias) based on measured radiochemical assay data, as described in Section 2.2.1.4.1.1.2.4.1, rather than a calculational adjustment that varies with increasing burnup.

Genuine Dispute [10 C.F.R. 2.309(f)(1)(vi)]: Sections 2.2.1.4.1.1.2.1, 2.2.1.4.1.1.2.2, and 2.2.1.4.1.1.2.4.1 of the LA SAR apply several assumptions in the postclosure criticality analysis that would establish de facto cask design requirements that in turn would dictate the insertion of disposal control rod assemblies into some fuel assemblies prior to disposal. NEI disputes these sections of the SAR with regard to the need to impose these particular assumptions that are excessively conservative.

As noted above, NEI's expert contends that assumptions, related to (1) flooding, (2) neutron absorber thickness, (3) neutron absorber content credit, (4) cooling time and (5) uncertainty calculations are excessively conservative and unnecessary to ensure a reasonable postclosure criticality analysis.

Joint Sponsors: None.

NEI - SAFETY - 06: Drip Shields Are Not Necessary

Contention [10 C.F.R. 2.309(f)(1)(i)]: The drip shields that the Department of Energy ("DOE") proposes as part of the Engineered Barrier System ("EBS") are not necessary because the repository is capable of meeting regulatory requirements with significant performance margin and defense in depth without drip shields. Installation of the drip shields will result in significant and unnecessary radiation exposures, resource use, and costs, and is therefore inconsistent with "as low as is reasonably achievable" ("ALARA") principles.

Basis [10 C.F.R. 2.309(f)(1)(ii)]: The technical basis for proposed Contention NEI-SAFETY-06 is set forth in detail in an affidavit from qualified experts, Dr. Matthew W. Kozak, Dr. Michael J. Apted, and Dr. Fraser King (included with the NEI Petition at Attachment 13), who explain that the repository design includes titanium "drip shields" between the waste packages and the repository drift walls to prevent seepage water from dripping onto the waste packages and to protect the waste packages from falling rocks. DOE's analyses of post-closure performance include several overly conservative assumptions that have led DOE to unnecessarily include drip shields in its repository design, including excessive conservatisms with respect to: (1) the flow rate of water into the drift; (2) the failure rates of waste packages; (3) the robustness of the waste packages to seismic-induced localized corrosion; (4) damage that could occur to a waste package from dynamic impacts from falling rocks; and (5) the damage that could be produced to a waste package from the static loading of rocks built up following a seismic event. In addition, DOE's analyses take no credit for the performance of the inner stainless steel canister. Without the drip shields, the repository will comply with regulatory requirements with significant performance margin, and little additional performance margin is gained by their installation. The installation of the drip shields will result in significant and unnecessary radiation exposures, and is therefore inconsistent with ALARA principles. Such installation will also result in significant, unnecessary resource and cost expenditures.

Scope of Proceeding [10 C.F.R. 2.309(f)(1)(iii)]: The issue raised in this contention is within the scope of this proceeding as it relates to the Nuclear Regulatory Commission's ("NRC's" or "Commission's") Atomic Energy Act ("AEA") and Nuclear Waste Policy Act ("NWPA") responsibilities. As discussed below, it raises an issue that is material to the findings that the NRC must make to support issuance of a license.

Materiality [10 C.F.R. 2.309(f)(1)(iv)]: 10 C.F.R. § 50.40 and 10 C.F.R. § 63.111 provide, respectively, that (1) reactor licensees and (2) the geologic repository operations area must meet the requirements of 10 C.F.R. Part 20. 10 C.F.R. § 20.1002 provides that Part 20 applies to persons holding NRC licenses under 10 C.F.R. Part 50 and 10 C.F.R. Part 63. 10 C.F.R. § 20.1101(b) states that "licensee[s] shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are [ALARA]," and 10 C.F.R. § 20.1003 defines "ALARA" as "making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest." Here, the repository will comply with regulatory requirements with significant performance margin without titanium drip shields, and the fabrication and installation of the drip shields will thus result in (1) unnecessary radiation exposures to repository site workers; (2) unnecessary use of resources; and

(3) the unnecessary expenditure of billions of dollars. Hence, the repository design's inclusion of titanium drip shields is not consistent with ALARA principles.

Facts, Opinions, and References [10 C.F.R. 2.309(f)(1)(v)]: NEI's contention that the repository design's inclusion of drip shields is inconsistent with ALARA principles is based on the following facts and opinions, as set forth in detail in the Affidavit of Drs. Kozak, Apted, and King:

a. As proposed, the repository's design includes the installation of titanium drip shields between the waste packages and the drift walls prior to permanent closure of the repository. *See* Kozak, Apted, and King Affidavit at ¶¶ 28-30.

b. The repository design's inclusion of drip shields is based on unnecessary over-conservatisms in DOE's analyses with respect to (1) the need to divert seepage water away from the waste package; and (2) the need to protect the waste package from rockfall. *Id.* at ¶ 31.

c. With respect to the asserted need to protect the waste packages from seepage, DOE's analyses are already conservative because they are based in part on conservative assumptions regarding future climate conditions proposed by the NRC, which assume high rates of water percolation at the repository horizon. *Id.* at ¶¶ 34-35. DOE's conclusions are the result of compounding two additional conservative assumptions on top of the assumed climate conditions. Those two additional conservative assumptions are (1) a high seepage rate and seepage fraction, *id.* at ¶ 37 & Table 1; and (2) a constant, higher rate of localized corrosion that fails to account for stifling, *id.* at ¶ 39-40.

d. With respect to the asserted need to protect the waste packages from rockfall, DOE's conclusions are the result of compounding several conservative assumptions, including (1) an overestimation of the seismic hazard, *id.* at ¶¶ 44-47; and (2) an overestimation of damage to the waste packages from both static and dynamic rockfall loads, *id.* at ¶¶ 48-53. The overestimation of damage to waste packages leads to an overestimation of stress corrosion cracking of the waste package, *id.* at ¶¶ 54-62, an overestimation of the relative importance of waste package failure caused by rockfall, *id.* at ¶¶ 63-67, and ultimately an underestimation of containment in the engineered barrier system by failing to credit the stainless steel canister in which SNF will be stored. *Id.* at ¶¶ 68-69.

e. Without drip shields, the repository will comply with regulatory requirements with significant performance margin. *Id.* at ¶¶ 70-71.

f. The installation of titanium drip shields will result in significant and unnecessary (1) radiation exposures to site workers; (2) resource use, including tens of thousands of tons of titanium; and (3) costs, which will exceed several billion dollars. *Id.* at ¶¶ 72-74. Thus, the repository design's inclusion of drip shields is inconsistent with ALARA principles. *Id.* at ¶¶ 75.

Genuine Dispute [10 C.F.R. 2.309(f)(1)(vi)]: LA Safety Analysis Report ("SAR") Section 2.3.6.2 states that the repository design includes drip shields to prevent seepage waters from contacting the waste packages and to protect the waste package from rockfall. LA SAR Section 2.1.1.2 states that the drip shield is important to waste isolation ("ITWI"). NEI disputes these provisions and the need for drip shields to be installed. As discussed above, drip shields are not necessary to meet repository regulatory requirements. Furthermore, with regard to ALARA cost benefit principles, the increased near term radiation exposures that will be incurred to install them are not warranted given the minimal long-term performance benefit that is accrued by their inclusion as part of the design.

Joint Sponsors: None.

NEI - NEPA - 01: Inadequate NEPA Analysis for 90% TAD Canister Receipt Design

Contention [10 C.F.R. 2.309(f)(1)(i)]: The Yucca Mountain Final Supplemental Environmental Impact Statement ("FSEIS") fails to analyze reasonably foreseeable environmental impacts that will result from DOE's proposal to receive up to 90% of spent nuclear fuel ("SNF") at Yucca Mountain in Transport, Aging, and Disposal ("TAD") canisters.

Basis [10 C.F.R. 2.309(f)(1)(ii)]: The technical basis for proposed Contention NEI-NEPA-01 is set forth in detail in an affidavit from qualified experts Brian Gutherman, Thomas E. Magette, and Richard A. Loftin (included with the NEI Petition at Attachment 14), who explain that the Yucca Mountain License Application ("LA") states that the repository surface facilities are designed to receive at least 90% of commercial SNF at the repository in TAD canisters (loaded at reactor sites). This will result in some commercial SNF already loaded into dual-purpose canisters ("DPCs") and transportable bare fuel casks ("BFCs") being unloaded and reloaded into TAD canisters at reactor sites. The Department of Energy's ("DOE's") FSEIS fails to analyze the environmental impacts from having to unload DPCs and BFCs and reload TAD canisters at reactor sites, including the additional low-level radioactive waste that will result from the discarded DPCs and BFCs, and the environmental impacts associated with transporting the discarded DPCs and BFCs.

Scope of Proceeding [10 C.F.R. 2.309(f)(1)(iii)]: The issue raised in this contention is within the scope of this proceeding because it relates to the Nuclear Regulatory Commission's ("NRC's") National Environmental Policy Act ("NEPA") and Nuclear Waste Policy Act ("NWPA") responsibilities. DOE's failure to analyze reasonably foreseeable environmental impacts that will result from this aspect of its proposed repository design constitutes "new considerations [that] render [its] environmental impact statement in adequate." 10 C.F.R. § 51.109(c)(2). The issues raised herein meet the requirements of 10 C.F.R. § 51.109(a)(2) (referring to the standards for motions to reopen under 10 C.F.R. § 2.326). DOE's failure to analyze these reasonably foreseeable environmental impacts is timely raised in this petition for intervention and concerns a significant environmental issue. Had DOE initially analyzed these impacts, its EIS would have been altered. This contention is accompanied by the affidavit of Messrs. Gutherman, Magette, and Loftin. As discussed below, this contention raises an issue that is material to the findings that the NRC must make to support issuance of a license.

Materiality [10 C.F.R. 2.309(f)(1)(iv)]: 10 C.F.R. § 63.21(a) requires that DOE prepare an environmental impact statement ("EIS") in accordance with the NWPA, which must accompany the safety analysis report. 10 C.F.R. § 63.24(c) requires that DOE supplement its EIS in a timely manner so as to "take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts." 10 C.F.R. § 63.41(e) requires that "[a]ll applicable requirements of part 51 of this chapter have been satisfied." 10 C.F.R. § 51.67 requires that, in lieu of an environmental report, DOE submit to the NRC the EIS it prepares in connection with a geologic repository and supplement that EIS if circumstances warrant. 10 C.F.R. §51.45 (b)(1) requires that an environmental report discuss "[t]he impact of the proposed action on the environment. Impacts shall be discussed in proportion to their significance." Here, the FSEIS fails to discuss any of the environmental impacts resulting from DOE's proposal to receive up to 90% of spent nuclear fuel at Yucca Mountain in TAD canisters.

Facts, Opinions, and References [10 C.F.R. 2.309(f)(1)(v)]: NEI's contention that the FSEIS fails to discuss any of the environmental impacts resulting from DOE's proposal to receive up to 90% of spent nuclear fuel at Yucca Mountain in TAD canisters is based on the following facts and opinions, as set forth in detail in the affidavit of Messrs. Gutherman, Magette, and Loftin:

a. As proposed, the LA requires that all commercial SNF to be disposed of in the Yucca Mountain repository – 63,000 metric tons of heavy metal ("MTHM") – be loaded into TAD canisters prior to disposal. Gutherman, Magette, and Loftin Affidavit at ¶¶ 22-23, 26.

b. DOE has designed the repository surface facilities to receive at least 90% of commercial SNF in TAD canisters, but only up to 10% of commercial SNF (6,300 MTHM) in transportable canisters and casks. *Id.* at ¶ 27.

c. By the time Yucca Mountain is expected to open in 2020, at least 14,354 MTHM of U.S. commercial SNF will reside in transport-licensed DPCs and BFCs, which exceeds the 10% allotment for non-TAD SNF by (at least) 8,054 MTHM. *Id.* at ¶¶ 36-37.

d. Assuming on average that 13 MTHM SNF are stored in each DPC or BFC, the 8,054 MTHM of commercial SNF in excess of DOE's 10% non-TAD receipt design will require that approximately 620 DPCs and BFCs will have to be unloaded and reloaded into TADs at reactor sites. This would result in approximately 620 discarded DPCs and BFCs. *Id.* at ¶ 39.

e. The approximately 620 discarded DPCs and BFCs would be low-level radioactive waste ("LLRW"), and depending on the class of LLRW and the geographic location of the LLRW, utilities may have limited or no disposal options for the LLRW. Furthermore, the LLRW will require transport over long distances for disposal. *Id.* at ¶¶ 40-42.

f. DOE fails to analyze the environmental impacts and costs of the LLRW waste that will be generated, and transportation of that LLRW, as a result of DOE's proposed action to accept at least 90% of commercial SNF in TAD canisters at Yucca Mountain. *Id.* at ¶¶ 43-50.

Genuine Dispute [10 C.F.R. 2.309(f)(1)(vi)]: LA General Information Section 1.2.2 states that the surface facilities have been designed to support a mostly canisterized waste stream, and that the repository objective is to have 90% of individual commercial SNF assemblies loaded into TAD canisters by the utilities, with the remaining quantity of SNF arriving at the repository in DPCs or transportation casks. LA SAR Section 1.5.1.1 states that the repository shall be capable of accepting, transporting, and disposing of commercial SNF where at least 90% is received in TAD canisters and no more than 10% is received in DPCs or bare fuel casks. NEI disputes the failure of the FSEIS to analyze the environmental impacts that will result from the surface facility's 90% TAD receipt design, namely the transportation, disposal, and costs associated with the LLRW that will be generated at reactor sites.

Joint Sponsors: None.

NEI - NEPA - 02: Overestimate of Number of Truck Shipments

Contention [10 C.F.R. 2.309(f)(1)(i)]: The Yucca Mountain Final Supplemental Environmental Impact Statement ("FSEIS") overestimates the radiological exposures that reactor and Yucca Mountain site workers will receive because it overestimates the number of spent nuclear fuel ("SNF") shipments to Yucca Mountain that will occur by truck.

Basis [10 C.F.R. 2.309(f)(1)(ii)]: The technical basis for proposed Contention NEI-NEPA-02 is set forth in detail in an affidavit from a qualified expert, Brian Gutherman (included with the NEI Petition at Attachment 15), who explains that FSEIS Table G-10 overestimates the number of truck shipments of commercial SNF to Yucca Mountain and therefore underestimates the number of rail shipments that will be required to ship commercial SNF to Yucca Mountain. A more realistic estimate of shipping would result in greater reliance on rail shipping, a lower number of truck shipments, and therefore fewer overall shipments. Thus, DOE overstates the radiation exposure to workers at Yucca Mountain and reactor sites.

Scope of Proceeding [10 C.F.R. 2.309(f)(1)(iii)]: The issue raised in this contention is within the scope of this proceeding because it relates to the Nuclear Regulatory Commission's ("NRC's" or "Commission's") National Environmental Policy Act ("NEPA") and Nuclear Waste Policy Act ("NWPA") responsibilities. DOE's overestimation of the number of SNF shipments that will occur by truck constitutes "new considerations [that] render [its] environmental impact statement in adequate." 10 C.F.R. § 51.109(c)(2). The issues raised herein meet the requirements of 10 C.F.R. § 51.109(a)(2) (referring to the standards for motions to reopen under 10 C.F.R. § 2.326). DOE's overestimation of the number of SNF shipments that will occur by truck is timely raised in this petition for intervention and concerns a significant environmental issue. Had DOE correctly estimated these shipments, its EIS would have been altered. This contention is accompanied by the affidavit of Mr. Gutherman. As discussed below, this contention raises an issue that is material to the findings that the NRC must make to support issuance of a license.

Materiality [10 C.F.R. 2.309(f)(1)(iv)]: 10 C.F.R. § 63.21(a) requires that DOE prepare an environmental impact statement ("EIS") in accordance with the Nuclear Waste Policy Act of 1982, as amended, which must accompany the safety analysis report. 10 C.F.R. § 63.24(c) requires that DOE supplement its EIS in a timely manner so as to "take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts." 10 C.F.R. § 63.41(e) requires that "[a]ll applicable requirements of part 51 of this chapter have been satisfied." 10 C.F.R. § 51.67 requires that DOE, in lieu of an environmental report, submit to the NRC the EIS it prepares in connection with a geologic repository and supplement that EIS if circumstances warrant. 10 C.F.R. §51.45 (b)(1) requires that an environmental report discuss "[t]he impact of the proposed action on the environment. Impacts shall be discussed in proportion to their significance." Here, DOE's EIS fails to discuss the impacts of the repository in proportion to their significance because DOE overestimates the number of truck shipments of SNF that will occur.

Facts, Opinions, and References [10 C.F.R. 2.309(f)(1)(v)]: NEI's contention that the FSEIS overestimates the radiological exposures that reactor and Yucca Mountain site workers will receive because it overestimates the number of truck shipments to Yucca Mountain that will occur by truck is based on the following facts and opinions, as set forth in detail in the affidavit Mr. Gutherman:

a. DOE bases the estimate of the radiological exposure to workers and members of the public from the preparation and transportation of SNF and high-level waste shipments to the Yucca Mountain repository, in part, on the commercial SNF shipments that DOE assumes will occur by truck. Gutherman Affidavit at ¶ 16.

b. FSEIS Table G-10 assumes that seven commercial reactor sites will transport SNF to Yucca Mountain by truck. However, it is public knowledge that six of those sites will place SNF in dry storage at on-site Independent Spent Fuel Storage Installations (“ISFSIs”) in dual-purpose canisters (“DPCs”). These DPCs are designed to be shipped offsite in rail cask-sized shipping packages weighing approximately 125 tons each. Therefore, these six commercial plants will likely ship their SNF to the Yucca Mountain repository by rail, not by truck. *Id.* at ¶ 18.

c. It is not clear whether the DOE will accept this commercial SNF in DPCs or if it will have to be reloaded into Transportation, Aging, and Disposal (“TAD”) canisters, which are also designed to be shipped by rail, given DOE’s objective to receive at the repository 90% of commercial SNF in TAD canisters. This contention conservatively assumes that commercial SNF will be transported in TAD canisters. This is conservative because it takes more TAD shipments than DPC shipments to transport the same amount of commercial SNF. *Id.* at ¶ 20.

d. Shipping the commercial SNF by rail in TAD canisters rather than truck casks will require far fewer packages to be prepared for shipment: 838 rail cask-size TAD canisters versus 2,319 truck casks, or 1,481 fewer packages to be prepared for shipment. *Id.* at ¶ 24.

e. FSEIS Table G-2 estimates 0.432 person-rem of worker radiation exposure to load each batch of uncanistered SNF into a truck cask and load the truck cask onto a truck trailer. Thus, the total radiation worker dose to load 2,319 truck casks is approximately 1,000 person-rem using DOE's dose values. *Id.* at ¶ 25.

f. Table G-2 of the Yucca Mountain FSEIS provides DOE's estimate 0.663 person-rem of worker radiation exposure to transfer a TAD canister from storage, load into a rail cask, and load the rail cask onto a rail car. Thus, the total radiation worker dose to load 838 rail cask-size shipping packages is estimated to be 555 person-rem. *Id.* at ¶ 26.

g. Accordingly, DOE's erroneous assumption about the truck shipments to Yucca Mountain overstates the worker dose at reactor sites by at least 445 person-rem. *Id.* at ¶ 27.

h. Furthermore, the difference in radiation dose for the handling and preparation of truck casks and rail casks at reactor sites (~445 person-rem) would likely be comparable to the difference in radiation dose for the receipt and handling of truck casks and rail casks at the repository. *Id.* at ¶ 28.

i. Thus, DOE overstates the radiation exposure to workers at reactor sites and at the proposed Yucca Mountain repository. *Id.* at ¶ 29.

Genuine Dispute [10 C.F.R. 2.309(f)(1)(vi)]: FSEIS Table G-10 assumes that the SNF from seven commercial reactor sites will be transported by truck, when it is public knowledge that six of these sites will store their SNF in rail transportable canisters. The assumption that these sites will use truck shipments when in fact they will use rail shipments results in overestimates of incurred radiation doses and of the cost of the program. This results in a failure of the environmental documents to discuss repository impacts in proportion to their significance.

Joint Sponsors: None.

NEI - NEPA - 03: Over-Conservatism in Sabotage Analysis

Contention [10 C.F.R. 2.309(f)(1)(i)]: The Final Supplemental Environmental Impact Statement (SEIS) for the Yucca Mountain repository, in Section 4.1.8.4, discusses environmental consequences of hypothetical terrorist attacks at the repository site. (The sabotage analysis for a "representative scenario" is also presented in Appendix E of the SEIS.) The SEIS, in Section 6.3.4, also discusses transportation sabotage events and consequences. These discussions of the consequences of highly unlikely and speculative scenarios are unreasonable and unnecessary. Moreover, the analyses are based on unrealistic, overly conservative assumptions that result in hypothetical impacts that are significantly over-estimated.

Basis [10 C.F.R. 2.309(f)(1)(ii)]: The basis for this contention is set forth in the following three letters presenting NEI's comments on DOE's analyses of sabotage events and consequences as discussed, respectively, in (1) DOE's notice of intent to supplement the final environmental impact statement for the Yucca Mountain repository, (2) the draft SEIS for the Yucca Mountain repository, and (3) the draft SEIS related to rail transportation for the repository:

- NEI Letter from R. McCullum to J. Summerson, DOE, dated December 12, 2006 ("Nuclear Energy Institute Comments on the U.S. Department of Energy Notice of Intent: *Supplement to the Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, 71 Federal Register 60490, October 13, 2006")(LSN Acc. No. DEN001599158).
- NEI Letter from R. McCullum to J. Summerson, DOE, dated January 9, 2008 ("Nuclear Energy Institute Comments on the Draft Supplemental

Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada")(LSN Acc. No. NEN000000671).

- NEI Letter from S. Kraft to J. Summerson, DOE, dated January 9, 2008 ("Nuclear Energy Institute Comments on the Draft Supplemental Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada — Nevada Rail Transportation Corridor; and the Draft Environmental Impact Statement for a Rail Alignment for the Construction and Operation of a Railroad in Nevada to a Geologic Repository at Yucca Mountain, Nye County, Nevada")(LSN Acc. No. NEN000000676).

In its comments, NEI has maintained that used fuel storage and transportation canisters are extremely robust and highly resistant to sabotage. A defense-in-depth design philosophy makes these canisters resistant to terrorist attacks. Also, given the security requirements that will be in place for the repository and spent fuel shipments, the remote location of the repository, and the available mitigation measures, the repository and transportation casks are not attractive targets and terrorist attacks are not likely to be successful. The extreme conservatism of DOE's approach diminishes the value of the SEIS as a public communications tool, because it could raise concerns that are not justified, increase licensing uncertainty, and delay licensing of the repository.

Inclusion of the terrorist scenario in the Yucca Mountain repository SEIS is apparently intended to be responsive to the decision of the Ninth Circuit Court of Appeals in *San Luis Obispo*

Mothers for Peace v. NRC, 449 F. 3d 1016 (9th Cir. 2006), *cert.* denied 127 S. Ct. 1124 (2007). However, that decision, applying the National Environmental Policy Act (NEPA), does not compel an evaluation of consequences of remote and speculative scenarios. In that decision the Court of Appeals held — in connection with licensing of an Independent Spent Fuel Storage Installation at the Diablo Canyon Power Plant site — that:

> The appropriate inquiry is . . . whether such attacks are so "remote and highly speculative" that NEPA's mandate does not include consideration of their environmental effects.

San Luis Obispo Mothers For Peace, 449 F.3d at 1028. The Court of Appeals continued:

> We conclude it was unreasonable for the NRC to categorically dismiss the possibility of a terrorist attack on the Storage Installation and in the entire Diablo Canyon facility as too "remote and highly speculative" to warrant consideration under NEPA.

Id. The Court's decision, therefore, by no means directed that federal agencies evaluate the consequences of hypothetical terrorist attacks. Rather, it mandated in a particular case that the NRC develop a record on the question of whether such scenarios are "remote and highly speculative" prior to concluding that consequences do not warrant further consideration. In the present case involving Yucca Mountain, DOE has overlooked the important threshold question and proceeded in the SEIS to present speculative, and misleading, analyses of terrorist scenarios — both at the facility and during transportation of used fuel canisters. The analyses simply assume an attack that is successful, with failures of either the repository facilities or the transportation canisters, with assumed releases of radiological materials.

Finally, consistent with the NRC's longstanding view, NEI contends that NEPA does not require the NRC to consider environmental impacts unless there is a "reasonably close causal relationship" between the federal agency action and the impacts. *See, e.g., Department of Transportation v. Public Citizen*, 541 U.S. 752, 767 (2004), *citing Metropolitan Edison v. People*

Against Nuclear Energy, 460 U.S. 766, 774 (1983). The two Supreme Court decisions demonstrate that NEPA should not be construed to force agencies to consider environmental impacts for which they are not responsible. The NRC does not routinely require such consequence assessments in its licensing reviews and hearings, and should not do so for Yucca Mountain. *See AmerGen Energy Company, LLC* (License Renewal for Oyster Creek Nuclear Generating Station), CLI-07-08, ___ NRC ___ (2007). The Ninth Circuit decision in *San Luis Obispo Mothers for Peace* should be limited to its particular facts, involving an Independent Spent Fuel Storage Installation co-located at the site of a power reactor.[10]

Scope of Proceeding [10 C.F.R. 2.309(f)(1)(iii)]: The issue raised in this contention is within the scope of this proceeding. It raises an issue that is specifically addressed in the Yucca Mountain repository SEIS as well as the rail transportation SEIS, and questions the need for, as well as the conservatism of, the DOE analyses. As discussed further below, the contention is also germane to the issue of adoption of the DOE SEIS and to the NEPA findings that NRC will make to support the issuance of a license.

Materiality [10 C.F.R. 2.309(f)(1)(iv)]: NEI's contention challenges DOE's analyses of the likelihood and consequences of terrorist attacks at the Yucca Mountain repository and on spent

10 For example, in the matter addressed in *San Luis Obispo Mothers for Peace*, the petitioners were focused on the fact that the proposed ISFSI would be co-located with a power plant, and were attempting to use the ISFSI licensing proceeding as a means to challenge continued operation of the plant itself. *San Luis Obispo Mothers for Peace*, 449 F.3d at 1026. The Court directed the NRC, in its response to the remanded question of whether the possibility of an attack is "too far removed" or too speculative to be considered, to specifically address whether the licensing of the ISFSI "would lead to or increase the risk of a terrorist attack because: (1) the presence of the Storage Installation would increase the probability of a terrorist attack on [the co-located power reactor]; and (2) the Storage Installation itself would be a primary target for a terrorist attack" given the presence of the power reactor. *Id*. at 1030. Clearly, the site-specific context of the ISFSI was a major factor leading the Court of Appeals to remand for further development of the record on the threshold question.

nuclear fuel in transit to the repository. The proposed contention is material to this proceeding under NEPA, 42 U.S.C. § 4321, *et seq*., which among other things requires, for major federal actions, "a detailed statement" of the environmental impacts of the proposed action. *See* 42 U.S.C. § 4332(C)(i). Under NRC's regulations, the contention is material to the issue of the NRC's adoption of the SEIS under 10 C.F.R. §§ 51.109(b) and (c), and to the findings the NRC must make on the benefits and costs of the project under 10 C.F.R. § 51.109(e). As also discussed above, the DOE analysis is not consistent with governing legal precedent and NRC policy.

Facts, Opinions, and References [10 C.F.R. 2.309(f)(1)(v)]: The facts, opinions, references and legal arguments of NEI are those set forth above and in the NEI comment letters referenced above. NEI's position includes the following:

a. NEPA does not compel an evaluation of the *consequences* of hypothetical terrorist attacks in this case. The scenarios outlined by DOE in the SEIS are "remote and speculative" and not "reasonably foreseeable" under NEPA. The SEIS itself sufficiently establishes on a site-specific basis that terrorist attacks are unlikely and that further analysis of speculative consequences are misleading and do not promote meaningful agency decisionmaking. The record on this point is reflected in the SEIS:

1. Section 4.1.8.4 of the SEIS (at 4-72 to 4-78) outlines various considerations that reduce the threat of sabotage at the Yucca Mountain repository site. These include: security requirements to prevent terrorists from gaining control of commercial aircraft; the safety and security (post-closure) provided by deep geologic disposal of spent nuclear fuel in robust

waste packages; the remote location and restricted access of the proposed repository for pre-closure storage; the restricted airspace surrounding the site as well as access to a "highly effective" rapid-response security force; and the security regulations applicable to storage of spent nuclear fuel at the site. These factors, taken together with the robust design of the storage and transportation canisters, make the Yucca Mountain site an unattractive and unlikely target for terrorist attacks.

2. Section 6.3.4 of the SEIS (at 6-24 to 6-25) discusses transportation sabotage considerations. DOE again references many of the factors noted above that make terrorist attacks on transportation canisters very unlikely and speculative events. In addition, DOE notes NRC rules and compensatory measures promulgated subsequent to September 11, 2001, specifically to protect the public from harm that could result from sabotage of spent nuclear fuel casks. These measures include: armed escorts for fuel shipments; safeguarding of shipment schedule information; and monitoring of shipments and coordination among state and federal agencies. These factors are combined with the stringent structural, thermal, shielding and criticality requirements applicable to certified storage and transportation casks that provide high assurance of confinement integrity. In this context, DOE's decision to evaluate in the SEIS the consequences of an aircraft crash into a spent nuclear fuel cask and an attack with "a modern weapon (high-energy-density device)" are grossly speculative, unreasonable, and unnecessary.

b. Even if an evaluation of the consequences of a terrorist event is required or performed, the analysis must be reasonable in order to properly inform the public and agency decisionmakers. The SEIS evaluations are overly conservative in several specific respects:

1. Based on information presented in the draft SEIS, in Section 4.1.8.4 and Appendix E, NEI has previously commented on the specific input assumptions regarding the response to sabotage events. For example, DOE's analysis, as summarized in Appendix E, Section E.7, of the final SEIS, assumes evacuation of the affected population only after 24 hours. This evacuation time may reflect a bounding approach, but is longer than would actually be the case and therefore does not lead to reasonable results.

2. NEI has also previously commented on other conservative assumptions in the DOE analysis, such as the release fractions summarized in SEIS Section 6.1.11 and reflected in the analysis presented in Section 6.3.4. The analysis remains overly conservative based on the assumptions utilized. For example, the release fractions do not take into account the additional barrier that a TAD canister would add in a sabotage scenario. Moreover, the SEIS assumes that a PWR TAD package would hold 21 assemblies; nonetheless, DOE chose to estimate the consequences of a rail sabotage event based on the radionuclide inventory in 26 PWR assemblies. Presenting the results of an overly conservative consequence analysis is not appropriate.

c. As discussed above, NEI continues to maintain — as does the NRC — that NEPA does not compel an analysis of environmental impacts that are not proximately caused by the agency action. In this respect, NEI agrees with the NRC that the Ninth Circuit Court of Appeals did not properly apply prior Supreme Court NEPA doctrine in *Metropolitan Edison Co. v. People Against Nuclear Energy* and *Department of Transportation v. Public Citizen*. Application of the Ninth Circuit decision should be limited to the specific facts of that case.

Genuine Dispute [10 C.F.R. 2.309(f)(1)(vi)]: The likelihood and hypothetical consequences of terrorist attacks at the Yucca Mountain repository site are discussed in several sections of the final SEIS, including Sections 4.1.8.4 and Appendix E, Section E.7 (the "representative" sabotage scenario). The likelihood and hypothetical consequences of transportation sabotage are discussed in Section 6.3.4 of the SEIS.[11] NEI disputes these sections of the SEIS.

As noted above, NEI contends that (and there is a genuine dispute regarding whether) the record is sufficient to establish that the Yucca Mountain repository is neither an attractive nor likely target for terrorist attacks as a matter of fact, and therefore that an evaluation of hypothetical consequences for remote and speculative scenarios is not required as a matter of law. Further, NEI contends that (and there is a genuine dispute regarding whether) the consequences presented by DOE in connection with these scenarios are overly conservative because they are based on unreasonable assumptions. The assumptions in dispute relate to mitigation measures (such as

[11] Transportation sabotage scenarios are also discussed in the Rail Alignment EIS for the Caliente alignment in Section 4.2.10 (at 4-344 to 4-350) and the Mina alignment in Section 4.3.10 (at 4-728 to 4-734). Transportation sabotage scenarios are also discussed in Appendix K of the Rail Alignment EIS, at Section K.2.6, with results for the Caliente alignment in Section K.2.7.4 and for the Mina alignment in Section K.2.8.4.

timing of evacuation) and radiological source term and release fractions (such as those summarized in Section 6.1.11 of the SEIS).

Joint Sponsors: None.

IV. CONCLUSION

NEI respectfully requests that its petition to intervene be granted and that its specific contentions proposed herein be admitted for hearing.

Respectfully submitted,

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Dated in Washington, District of Columbia
this 19th day of December 2008

ATTACHMENT 1

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of:	)	
	)	
U.S. Department of Energy	)	Docket No. 63-001
(High Level Waste Repository)	)	
	)	

AFFIDAVIT OF RODNEY J. McCULLUM IN SUPPORT OF THE STANDING OF THE NUCLEAR ENERGY INSTITUTE

Rodney J. McCullum, being duly sworn, states as follows:

1. My name is Rodney J. McCullum. I am Director of the Yucca Mountain Project at the Nuclear Energy Institute, Inc. (NEI). I hold a Bachelor of Engineering degree in Nuclear Engineering (1985, University of Cincinnati) and a Master of Business Administration degree (2000, Lewis University). In my current position at NEI, I am responsible for developing and carrying out programs to achieve the goals of the nuclear energy industry with respect to the Yucca Mountain High Level Waste Repository.

2. NEI's members include all entities licensed to operate commercial nuclear power plants in the United States, nuclear plant designers, major architectural/engineering firms, fuel fabrication facilities, nuclear materials licensees, organizations involved in research and the uses of nuclear technologies in medical diagnosis and treatment, universities, unions, and other organizations and individuals involved in the nuclear energy industry or likely to be involved in the construction and operation of Yucca Mountain.

3. In January 1983, the Nuclear Waste Policy Act of 1982 (NWPA) was enacted "to provide for the development of repositories for the disposal of high-level radioactive waste and spent nuclear fuel." Congress found that "while the Federal Government has the responsibility

to provide for the permanent disposal of high-level radioactive waste and … spent nuclear fuel …, the costs of such disposal should be the responsibility of the generators and owners of such waste and spent fuel." (Section 111(a)(4).)

4. The NWPA directed the U.S. Department of Energy (DOE) "to establish a Nuclear Waste Fund, composed of payments made by the generators and owners of such waste and spent nuclear fuel," in order to ensure that "the costs of carrying out activities relating to the disposal of such waste and spent fuel will be borne by those persons responsible for generating such waste and spent fuel." (Section 11(b)(4).)

5. The NWPA authorized the Secretary of Energy to enter into contracts with the owners and operators of commercial nuclear power plants for the acceptance of title, subsequent transportation, and disposal of used nuclear fuel. The contracts were to provide for payment of a one (1.0) mil per kilowatt hour fee on electricity generated by civilian nuclear power reactors. The NWPA provided that, in return for the payment of fees, the Secretary, beginning not later than January 31, 1998, would dispose of the spent nuclear fuel. The NWPA required that the owners and operators of commercial nuclear power plants enter into contracts with the DOE or put at risk the operating licenses for their facilities. (Section 302.)

6. The Standard Contract for the Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste (Standard Contract), Title 10 U.S. Code of Federal Regulations, Part 961, was issued in final form by DOE in April 1983 and subsequently executed by nuclear companies. To date, however, in the absence of a licensed high level waste repository, DOE has not yet commenced accepting used nuclear fuel.

7. In October 2008 the DOE announced that it was ready to begin discussions with generating companies of a new Standard Contract for disposal of used fuel to be generated by

new nuclear plants currently in the NRC licensing process. Consistent with the NWPA, the new Standard Contract will obligate DOE to accept the used fuel. At least two generating companies (Duke Energy and Southern Nuclear) have now entered the new Standard Contract, a prerequisite to NRC licensing of a new facility.

8. The NWPA provides that the Secretary may make expenditures from the Nuclear Waste Fund for purposes of radioactive waste disposal activities. Payments from the fund are to cover all costs associated with used fuel disposal, including: identification of candidate sites; program management activities; research and development; transportation and packaging of used nuclear fuel; repository site characterization; repository design and engineering; performance analysis and performance confirmation; licensing activities such as the preparation of a license application and licensing proceedings; repository construction; repository operation; and repository decommissioning and closure. (Sections 11(a)(4), 302(d).)

9. NEI's members include the owners and operators of America's fleet of 104 operating commercial nuclear power plants. These reactor licensees currently pay over $700 million per year in fees into the Nuclear Waste Fund. Since its inception in 1983, more than $16 billion, excluding interest earned on the Fund, have been contributed by reactor licensees to pay for the Federal waste management program.

10. The NWPA requires that the generators and owners of used nuclear fuel have the primary responsibility to provide for the interim storage of used nuclear fuel until the used fuel is accepted by DOE and transported to a Federal facility. (Section 111(a)(5).)

11. The lack of an operational repository has placed nuclear power plants in the position of storing more used nuclear fuel for longer periods of time than originally intended and designed. The result is that many nuclear power plants have exhausted their original storage

capacity and have been forced to provide for additional onsite storage capacity. During the period of reactor operation, a nuclear power plant has two options to increase its used storage capacity: (1) by modifying the used fuel storage pool to move the stored assemblies closer together and thereby increase capacity; and (2) by constructing a dry storage facility onsite. After permanent plant shut-down and decommissioning, onsite dry storage becomes the only option available.

12. To present date, fuel pool modifications have been completed at practically every commercial nuclear power plant in the U.S. to increase storage capacity. Modifying a used fuel storage pool can cost from several million dollars to tens of millions of dollars, depending upon the amount of additional capacity that is gained. Modification costs include design, engineering, licensing, installation, and capital costs.

13. To present date, dry storage facilities have been established at 44 commercial reactor sites (7 of which no longer have an operating reactor). Dry storage systems use large, robust containers made of layers of steel or steel-reinforced concrete that is 18 or more inches thick. Costs for dry storage of used fuel will vary depending upon the type of dry storage technology selected, its licensing status, the needed capacity of the dry storage facility, and the length of time that fuel must be stored. For a 1,000 MTU facility we can make the following estimates. The up-front design, engineering, licensing, construction, and capital costs will range from $20 million to $25 million, depending upon the technology selected, type of equipment required, construction requirements, etc. Storage system capital and loading costs, including costs for storage casks or canisters, storage overpacks, loading, and consumables, are estimated to total $105 million to $175 million. Annual operating costs for a dry storage facility — including physical security — at an operating reactor site are approximately $500,000 per year.

If one assumes that dry storage will be needed to support 20 to 30 years of continued reactor operation, life cycle operating costs for dry storage at an operating reactor site will range from $10 million to $15 million. Dry storage facility decommissioning costs, estimated to be $3 million to $6 million, are costs associated with dismantling, decontaminating, and disposing of the material from the dry storage facility. Therefore, total life cycle costs to build and operate a 1,000 MTU dry storage facility to support a 20 to 30 year period during reactor operation are estimated to total between $138 million and $221 million.

14. There is also a significant cost burden associated with the continued storage of used nuclear fuel in pools or in dry storage during the period after a nuclear power plant has shut down for decommissioning. Post-shutdown used fuel storage costs include the costs to maintain the used fuel storage pools and/or dry storage facilities (again, including ongoing physical security requirements) until all used nuclear fuel has been removed from the nuclear power plant site and the facilities can be decontaminated and decommissioned. Annual operating costs for dry storage of used fuel are estimated to be less than the annual operating costs for pool storage. However, the capital cost to transfer the remaining used nuclear fuel to dry storage can be high, particularly for a multi-unit plant site.

15. If DOE does not begin to accept used nuclear fuel, the fuel could be stored at sites for 20 to 30 years, or longer, following cessation of reactor operations. Annual operating costs for a dry storage facility at a shutdown reactor site are approximately $3 million to $4 million per year. If one assumes that used nuclear fuel will have to be stored in dry storage for a 20 to 30 year period after a plant shuts down, the post-shutdown dry storage operating costs are estimated to be $60 million to $120 million. Annual operating costs for continued pool storage at a shutdown reactor site are approximately $8 million per year. If one assumes that pool storage

will continue for an additional 20 to 30 year period, the post-shutdown pool storage operating costs are estimated to be $160 million to $240 million. Actual costs may be higher or lower than the range presented due to site specific conditions.

16. A delay in decommissioning a nuclear power plant site due to the continued presence of used nuclear fuel on site would present other burdens in addition to the significant added costs of fuel storage discussed above. For example, nuclear fuel storage involves small occupational radiological exposures and requires operational planning and attention. The delay in the final decommissioning of the plant would also result in a continued encumbrance of the land due to the presence of used nuclear fuel at the site. This would prohibit reuse of the site for other beneficial purposes.

17. As shown herein, delays in the repository program will result in the owners and operators of nuclear power plants having to store greater quantities of used nuclear fuel for longer periods of time at significant cost and burden.

18. Overly conservative design elements of the proposed repository will also place unnecessary burdens on the owners and operators of nuclear power plants, as well as increased demands on the Nuclear Waste Fund. For example, design of an aging facility with excessive seismic design requirements would substantially delay availability of the repository, increase the cost of the aging facility, and increase occupational exposures at the facility site. Similarly, unnecessary drip shields would significantly delay availability of disposal and removal of fuel from onsite storage sites, and would significantly increase the cost of the repository project. Delay, as noted previously, would extend the burdens and costs of onsite used fuel storage.

19. A recent report issued by the Electric Power Research Institute (EPRI), Report No. 1018058, *"Occupational Risk Consequences of the Department of Energy's Approach to*

Repository Design, Performance Assessment and Operations in the Yucca Mountain License Application" (August 2008), LSN #000000720, highlights consequences of overly conservative design elements. For example, delays in the regulatory process caused by the inclusion of subjects that could be avoided (*e.g.*, unnecessary dry shields in the subsurface design) have the potential to slow down the licensing and construction processes. Inclusion of unnecessary elements in a final, approved design would also result in additional and unnecessary occupational risks for construction workers. In the case of drip shields, EPRI has estimated (at page 6-17) a total occupational radiation dose of 487.5 person-mrem if installation takes 5 years and 975 person-mrem if installation takes 10 years.

20. Conservatism in the proposed Yucca Mountain design would also result in other consequences for licensees who must store nuclear fuel or workers at Yucca Mountain. For example, the License Application currently states that all commercial spent nuclear fuel will be loaded into Transportation, Aging, and Disposal (TAD) canisters for disposal. This means that used fuel loaded into dual purpose canisters (DPC) must be unloaded and reloaded into TADs prior to disposal, either at reactor sites or at Yucca Mountain. This will cause unnecessary occupational exposures.

21. Another example is the conservatism in the License Application related to the post-closure criticality analysis. The conservatism is not consistent with industry practice and will result in installation of disposal control rod assemblies in some cases, causing occupational dose to workers, unnecessary expenses, and increased environmental costs.

22. In sum, delay in licensing of the proposed high level waste repository, or denial of the DOE license application, will impose on nuclear licensees the ongoing risks, burdens and costs associated with interim onsite storage of used nuclear fuel, as well as delays in releasing

the sites of decommissioned power reactors. Overly conservative design elements of the repository will also create occupational risks and exposures for workers at operating reactors and fuel storage installations, as well as workers at the Yucca Mountain site, and will unduly consume the Nuclear Waste Fund.

Rodney J. McCullum

Sworn and subscribed to before me this ___ day of December 2008.

Notary Public

My Commission expires: My Commission Expires August 14, 2012

ATTACHMENT 2

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of:	)	
	)	
U.S. Department of Energy	)	Docket No. 63-001
(High Level Waste Repository	)	
	)	
	)	

AFFIDAVIT OF J.A. STALL AUTHORIZING REPRESENTATION BY THE NUCLEAR ENERGY INSTITUTE

J.A. Stall, hereby duly sworn, states as follows:

1. I am the Executive Vice President and Chief Nuclear Officer of Florida Power & Light Company (FPL), FPL Energy Seabrook, LLC (FPLES), FPL Energy Duane Arnold, LLC (FPLEDA), and FPL Energy Point Beach, LLC (FPLEPB). All of the referenced companies are referred to collectively as the FPL Group Nuclear Companies and all are based in Juno Beach, Florida.

2. FPL operates four nuclear power reactors at two sites – St. Lucie Nuclear Plant, Units 1 and 2 in Jensen Beach, Florida, and Turkey Point Nuclear Plant, Units 3 and 4, in Florida City, Florida. FPL owns 100% of Turkey Point Units 3 and 4 and St. Lucie Unit 1; FPL owns 85.1% of St. Lucie Unit 2. FPLES owns 88.23% of and operates Seabrook Station in Seabrook, New Hampshire. FPLEDA owns 70% of and operates the Duane Arnold Energy Center in Palo, Iowa. FPLEPB owns and operates the Point Beach Nuclear Plant, Units 1 and 2, in Two Creeks, Wisconsin. All of the FPL Group Nuclear Companies are members of the Nuclear Energy Institute.

3. Turkey Point Units 3 and 4 have operated for 36 years. St. Lucie Unit 1 has operated for 32 years. St. Lucie Unit 2 has operated for 25 years. Since 1983, FPL has paid approximately $607 million into the Nuclear Waste Fund established by the Nuclear Waste Policy Act of 1982 (NWPA).

4. Seabrook Station has operated for 18 years. Since 1983, the owners of Seabrook Station have paid approximately $150 million into the Nuclear Waste Fund established by the NWPA.

5. Duane Arnold has operated for 36 years. Since 1983, the owners of Duane Arnold have paid approximately $111 million into the Nuclear Waste Fund established by the NWPA.

6. Point Beach Units 1 and 2 have operated for 36 years. Since 1983, the owners of Point Beach have paid approximately approximately $229 million into the Nuclear Waste Fund established by the NWPA.

7. Initially, used nuclear fuel at our power reactor sites was stored in the spent fuel pool for each reactor. Those pools have been modified over the years to increase the storage capacity, such as by installation of high density storage racks. The pool expansion projects involved significant design, engineering and construction costs, along with the related occupational exposures typical with work in and around the spent fuel pools. The pools and used fuel assemblies are also subject to ongoing surveillance and maintenance activities to assure continued compliance with applicable regulations and industry standards.

8. In 2008, FPL placed into operation an Independent Spent Fuel Storage Installation (ISFSI) to increase the on-site storage capacity for used fuel at St. Lucie Units 1 and 2. FPLES placed an ISFSI into operation at Seabrook in 2008. FPL is planning on placing an ISFSI into

operation at Turkey Point in 2011. The previous owners of Duane Arnold placed an ISFSI into operation at Duane Arnold in 2003. The previous owner of Point Beach placed an ISFSI into operation at Point Beach in 1995. The initial project costs for engineering, licensing, construction, and fuel loading of the St. Lucie ISFSI were approximately $54 million for the ISFSI. The initial project costs for the Seabrook ISFSI were approximately $37 million. Ongoing operation and maintenance costs for each ISFSI are approximately $5 million (which includes a dry cask loading campaign). These costs include ongoing physical security requirements that apply to the ISFSI, and will continue to apply until fuel is removed from the site. Those requirements have increased significantly since September 11, 2001. In addition, as with spent fuel pool storage, there are occupational exposures incurred in connection with the loading and routine operation of an ISFSI.

9. The FPL Group Nuclear Companies_support a license for the Yucca Mountain high level nuclear waste repository, and desires that the NRC licensing process be completed as expeditiously as possible, consistent with the time limits established by the NWPA, in order that DOE can meet its obligations to the nuclear industry. Any failure to license the project, or even a delay in licensing the project, will negatively impact the FPL Group Nuclear Companies and the industry. Such circumstances would increase the duration of onsite storage, with its related operational and financial impacts, occupational radiation exposures, and security requirements. Similarly, the lack of an offsite disposal facility will delay full decommissioning of the power reactor sites, and delay release of the site for unrestricted use, for as long as the fuel must remain at ISFSIs.

10. Concurrently, we believe that certain aspects of the design provided by DOE are overly conservative. We are concerned that these aspects could increase the licensing

uncertainty of the project, as well as the ultimate costs of construction of the repository once it is licensed. These issues have implications for expenditures by DOE from the Nuclear Waste Fund.

11. The FPL Group Nuclear Companies hereby authorize the Nuclear Energy Institute to request a hearing on its behalf and to represent its interests in that hearing in connection with the NRC licensing of the Yucca Mountain high level waste repository.

J.A. Stall
Executive Vice President and Chief Nuclear Officer
Florida Power & Light Company
FPL Energy Seabrook, LLC
FPL Energy Duane Arnold, LLC
FPL Energy Point Beach, LLC

Sworn and subscribed to before me this 9th day of December 2008.

HEATHER P. MELIGONIS
Notary Public - State of Florida
My Commission Expires Dec 6, 2009
Commission # DD 459125

Heather P. Meligonis
Notary Public

My Commission expires: 12/6/09

DC:574010.1

ATTACHMENT 3

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of:	)	
	)	
U.S. Department of Energy	)	Docket No. 63-001
(High Level Waste Repository	)	
	)	
	)	

AFFIDAVIT OF DHIAA M. JAMIL AUTHORIZING REPRESENTATION BY THE NUCLEAR ENERGY INSTITUTE

Dhiaa M. Jamil, hereby duly sworn, states as follows:

1. My name is Dhiaa M. Jamil, I am the Group Executive and Chief Nuclear Officer of Duke Energy Carolinas, LLC (Duke). Duke is a regulated utility based in Charlotte, North Carolina. Duke is a member of the Nuclear Energy Institute (NEI).

2. Duke is the licensed operator of seven nuclear power reactors at three sites. These nuclear stations are: the William B. McGuire Nuclear Station, Units 1 and 2; the Catawba Nuclear Station, Units 1, and 2; and the Oconee Nuclear Station, Units 1, 2, and 3. In addition to being the operator, Duke is the sole owner of the McGuire and Oconee units. Duke also owns an approximately 38.49% interest in Catawba, Unit 1

3. Each of the units has been in commercial operation for at least 20 years, and several for more than 25 years. In total, Duke has paid approximately $1.27 billion into the Nuclear Waste Fund established by the Nuclear Waste Policy Act of 1982 (NWPA).

4. Initially, used nuclear fuel at our power reactor sites was stored in the spent fuel pool for each reactor. Across the nuclear industry, most spent fuel pools have been modified

over the years to increase the storage capacity, such as by installation of high density storage racks. Duke has completed six of these spent fuel storage expansion projects at its sites. These projects involved significant design, engineering and construction costs, along with the related occupational exposures typical with work in and around the spent fuel pools. The pools and used fuel assemblies are also subject to ongoing surveillance and maintenance activities to assure continued compliance with applicable regulations and industry standards.

5. At each of the three power reactor sites, Duke has constructed an Independent Spent Fuel Storage Installation (ISFSI) to increase the on-site storage capacity for used fuel. ISFSI projects involve significant costs for engineering, licensing, construction, and fuel loading. In addition, there are significant and ongoing operation and maintenance costs for each ISFSI. These latter costs include expenditures related to ongoing physical security requirements that apply to an ISFSI, and that will continue to apply until fuel is removed from the site. In addition, as with spent fuel pool storage, there are occupational radiation exposures incurred in connection with the loading and routine operation of an ISFSI.

6. Duke supports a license for the Yucca Mountain high level nuclear waste repository, but there are certain aspects of the repository design proposed by DOE and the specifications for fuel canisters that could lead to unnecessary occupational radiation exposures at the power reactor sites as well as at Yucca Mountain. Moreover, some aspects of the DOE proposed design and specifications are overly conservative, could increase the licensing uncertainty of the project, and could increase the ultimate costs of construction of the repository once it is licensed. These issues have implications for expenditures by DOE from the Nuclear Waste Fund.

7. Duke desires that the NRC licensing process be completed as expeditiously as possible, consistent with the time limits established by the NWPA, in order that DOE can begin performing its obligations to the nuclear industry. Any failure to license the project, or even a delay in licensing the project, will negatively impact the company and the industry. Such circumstances would increase the duration of onsite storage, with its related operational, environmental, and financial impacts, occupational radiation exposures, and security requirements. Similarly, the lack of an offsite disposal facility will delay full decommissioning of the power reactor sites, and delay release of the sites for unrestricted use.

8. Duke hereby authorizes the Nuclear Energy Institute to request a hearing on its behalf and to represent its interests in that hearing in connection with the NRC licensing of the Yucca Mountain high level waste repository.

Dhiaa M. Jamil

Sworn and subscribed to before me this 12 day of December 2008.

DEBORAH S ROME NOTARY PUBLIC CATAWBA COUNTY, NC

Deborah S. Rome Deborah S. Rome
Notary Public

My Commission expires: 12/19/09

ATTACHMENT 4

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of:	)	
	)	
U.S. Department of Energy	)	Docket No. 63-001
(High Level Waste Repository	)	
	)	
	)	

AFFIDAVIT OF DAVID H. JONES AUTHORIZING REPRESENTATION BY THE NUCLEAR ENERGY INSTITUTE

David H. Jones, hereby duly sworn, states as follows:

1. My name is David H. Jones. I am over 21 years old. I am the Vice President of Engineering at Southern Nuclear Operating Company, Inc. (SNC). I have personal knowledge of the statements made in this affidavit.

2. SNC is based in Birmingham, Alabama, and operates 6 nuclear power reactors at 3 stations or sites. These nuclear stations are: Edwin I. Hatch Nuclear Plant (HNP) and Vogtle Electric Generating Plant (VEGP) located in Georgia and owned in part by Georgia Power Company (GPC), and in part by the Municipal Electric Authority of Georgia, the City of Dalton, Georgia, and Oglethorpe Power Corporation (the Co-Owners); and the Joseph M. Farley Nuclear Plant (FNP) located in Alabama and owned by Alabama Power Company (APC). SNC operates the nuclear stations as agent for GPC, the Co-Owners, and APC, and incurs expenses on their behalf. SNC is a member of the Nuclear Energy Institute.

3. Each nuclear station has two nuclear reactors referred to herein as Unit 1 and Unit 2. HNP Units 1 and 2 began operation in 1974 and 1978, respectively; FNP Units 1 and 2 began operation in 1977 and 1981, respectively, and VEGP Units 1 and 2 began operation in 1987 and 1989, respectively.

4. SNC has paid approximately $ 640.2 million on behalf of GPC into the Nuclear Waste Fund established by the Nuclear Waste Policy Act of 1982 (NWPA), and has paid approximately $315.3 million on behalf of APC into the Nuclear Waste Fund. Each year, SNC pays approximately $32 million in fees on behalf of GPC, and pays approximately $13 million in fees on behalf of APC.

5. Initially, spent nuclear fuel at SNC's power reactor sites was stored in the spent fuel pool for each reactor. Those pools have been modified over the years to increase the storage capacity, such as by installation of high density storage racks. The pool expansion projects involved significant design, engineering and construction costs, along with the related occupational exposures typical with work in and around the spent fuel pools. The pools and spent fuel assemblies are also subject to ongoing surveillance and maintenance activities to assure continued compliance with applicable regulations and industry standards.

6. In 2000, SNC placed into operation an Independent Spent Fuel Storage Installation (ISFSI) to increase the on-site storage capacity for spent fuel at HNP. Initial project costs for engineering, licensing, and construction were approximately $25,871,000. In addition, SNC has incurred and continues to incur substantial ongoing costs associated with acquistion of canisters and casks, spent fuel loading, operation and maintenance costs for the HNP ISFSI. In 2004, SNC placed into operation an ISFSI to increase the on-site storage capacity for spent fuel at the FNP. Initial project costs for engineering, licensing, and construction were approximately

$14,821,000. In addition, SNC has incurred and continues to incur substantial ongoing costs associated with acquisition of canisters and casks, spent fuel loading, operation and maintenance for the FNP ISFSI. In 1998, SNC reracked the spent fuel pool at the VEGP at a cost of approximately $2,716,000.

7. SNC supports a license for the Yucca Mountain high level nuclear waste repository, and desires that the NRC licensing process be completed as expeditiously as possible, consistent with the time limits established by the NWPA, in order that DOE can meet its obligations to the nuclear industry. Any failure to license the project, or even a further delay in licensing the project, will negatively impact the SNC and the industry. Such circumstances would increase the duration of onsite storage, with its related operational and financial impacts, occupational radiation exposures, and security requirements. Similarly, the lack of an offsite disposal facility will delay full decommissioning of the power reactor sites, and delay release of the site for unrestricted use, for as long as the spent fuel must remain at an ISFSI.

8. Concurrently, SNC sees certain aspects of the design provided by DOE that are overly conservative and that could increase the licensing uncertainty of the project, as well as the ultimate costs of construction of the repository once it is licensed. These issues have implications for expenditures by DOE from the Nuclear Waste Fund.

9. SNC hereby authorizes the Nuclear Energy Institute to request a hearing on its behalf and to represent its interests in that hearing in connection with the NRC licensing of the Yucca Mountain high level waste repository.

David H. Jones
Vice President of Engineering,
Southern Nuclear Operating Company, Inc.

STATE OF ALABAMA)
COUNTY OF SHELBY)

BEFORE ME, the undersigned authority, on this day personally appeared David H. Jones, a duly authorized officer for Southern Nuclear Operating Company, Inc., who is known to me to be the person who executed the foregoing instrument. Further, he executed and warranted that he had the authority to execute the same on behalf of said corporation.

Given under my hand and seal of office on December 11, 2008.

Charlotte A. Graham
NOTARY PUBLIC
My Commission Expires: 6/9/12

Notary Public

My Commission expires: 6/9/12

ATTACHMENT 5

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of:	)	
	)	
U.S. Department of Energy	)	Docket No. 63-001
(High Level Waste Repository	)	
	)	
	)	

AFFIDAVIT OF CHARLES G. PARDEE AUTHORIZING REPRESENTATION BY THE NUCLEAR ENERGY INSTITUTE

Charles G. Pardee, hereby duly sworn, states as follows:

1. My name is Charles G. Pardee. I am the President and Chief Nuclear Officer of Exelon Nuclear, and the Senior Vice President at Exelon Generation Company, LLC (Exelon Generation). Exelon Generation is based in Kennett Square, Pennsylvania, and operates 17 nuclear power reactors, with an additional 4 nuclear power reactors already shut down, at 11 stations or sites. These nuclear stations are: Braidwood Generating Station, Byron Generating Station, Clinton Power Station, Dresden Generating Station, LaSalle County Station, Limerick Generating Station, Oyster Creek Generating Station, Peach Bottom Atomic Power Station, Quad Cities Generating Station, Three Mile Island Generating Station, Zion Station.

2. Exelon Generation is a member of the Nuclear Energy Institute.

3. The Braidwood Nuclear Station has operated for 20 years. The Byron Nuclear Station has operated for 23 years. The Clinton Nuclear Station has operated for 21 years. The Dresden Nuclear Station has operated for 38 years. The LaSalle County Nuclear Station has operated for 26 years. The Limerick Nuclear Station has operated for 22 years. The Oyster

Creek Nuclear Station has operated for 39 years. The Peach Bottom Nuclear Station has operated for 34 years. The Quad Cities Nuclear Station has operated for 35 years. The Three Mile Island Nuclear Station has operated for 34 years. The Zion Nuclear Station operated for 29 years, and is no longer in operation.

4. Since 1983, for the nuclear plants that it now operates, either Exelon Generation or the previous owner of those units has paid approximately $ 2,711,722,566.75 into the Nuclear Waste Fund established by the Nuclear Waste Policy Act of 1982 (NWPA).

5. Initially, used nuclear fuel at our power reactor sites was stored in the spent fuel pool for each reactor. Those spent fuel pools have been modified over the years to increase the storage capacity, such as by installation of high density storage racks. The modification projects involved significant design, engineering and construction costs, along with the related occupational exposures typical with work in and around the spent fuel pools. The pools and used fuel assemblies are also subject to ongoing surveillance and maintenance activities to assure continued compliance with applicable regulations and industry standards.

6. To date, we have placed into operation an Independent Spent Fuel Storage Installation (ISFSI) to increase the on-site storage capacity for used fuel at the Dresden, Oyster Creek, Quad Cities, Peach Bottom, and Limerick Nuclear Stations. Additionally, we have begun engineering, licensing and construction work for new ISFSIs at our Byron, Braidwood and LaSalle Nuclear Stations. Initial project costs for engineering, licensing, construction, and fuel loading and ongoing operation and maintenance costs for the six completed ISFSIs and the three ISFSI in planning stages through November 2008 are approximately $313,795,000. These costs do not include ongoing physical security requirements that apply to the ISFSI, and will continue to apply until fuel is removed from the site. In addition, as with spent fuel pool storage, there are

occupational exposures incurred in connection with the loading and routine operation of an ISFSI.

7. Exelon Generation supports a license for the Yucca Mountain high level nuclear waste repository, and desires that the NRC licensing process be completed as expeditiously as possible, consistent with the time limits established by the NWPA, in order that DOE can begin performing its obligations to the nuclear industry. Any failure to license the project, or even a delay in licensing the project, will negatively impact the company and the industry. Such circumstances would increase the duration of onsite storage, with its related operational, environmental, and financial impacts, occupational radiation exposures, and security requirements. Similarly, the lack of an offsite disposal facility will delay full decommissioning of the power reactor sites (including Zion which is already shutdown), and delay release of the sites for unrestricted use.

8. Concurrently, we see certain aspects of the repository design proposed by DOE and the specifications for fuel canisters that could lead to unnecessary occupational radiation exposures at power reactor sites as well as at Yucca Mountain. Moreover, some aspects of the DOE proposed design and specifications are overly conservative, could increase the licensing uncertainty of the project, and could increase the ultimate costs of construction of the repository once it is licensed. These issues have implications for expenditures by DOE from the Nuclear Waste Fund.

9. Exelon Generation hereby authorizes the Nuclear Energy Institute to request a hearing on its behalf and to represent its interests in that hearing in connection with the NRC licensing of the Yucca Mountain high level waste repository.

Charles G. Pardee

Sworn and subscribed to before me this 12th day of December 2008.

"OFFICIAL SEAL"
CHRISTINE M. ARNDT
Notary Public, State Of Illinois
My Commission Expires June 15, 2009

Christine M Arndt
Notary Public

My Commission expires: 6/15/09

DC:574010.5

ATTACHMENT 6

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of:	)	
	)	
U.S. Department of Energy	)	Docket No. 63-001
(High Level Waste Repository	)	
	)	
	)	

AFFIDAVIT OF CHARLES V. SANS CRAINTE AUTHORIZING REPRESENTATION BY THE NUCLEAR ENERGY INSTITUTE

Charles V. Sans Crainte, hereby duly sworn, states as follows:

1. My name is Charles V. Sans Crainte, I am the Vice President, Generation of Dairyland Power Cooperative (Dairyland). Dairyland is a Wisconsin generation and transmission electric cooperative based in La Crosse, Wisconsin that owns and operates several power plants. Dairyland is a member of the Nuclear Energy Institute (NEI).

2. Dairyland is the owner and operator of the LaCrosse Boiling Water Reactor (LACBWR). LACBWR was designed and built by the Atomic Energy Commission as a second round demonstration plant in the Atoms for Peace program. LACBWR was completed in 1967, and the reactor was initially operated by the AEC while Dairyland built and operated the connected steam turbine generator that was driven by steam from the boiling water reactor/and the balance of the plant equipment. Upon commercial operation, Dairyland was the operator of the facility. In 1973, ownership of the reactor and fuel were transferred to Dairyland. LACBWR was permanently shut down and placed in SAFSTOR in April, 1987.

3. In total, Dairyland has paid approximately $4.5M into the Nuclear Waste Fund established by the Nuclear Waste Policy Act of 1982 (NWPA), representing the full payment called for under the NWPA for all of the fuel that Dairyland possesses at LACBWR.

4. At the time LACBWR was transferred to Dairyland, both Dairyland and the rest of the nuclear power industry expected that used nuclear fuel would be reprocessed and would not become a long-term storage issue. Reprocessing of spent fuel in the United States was terminated through a Presidential executive order in 1977. Spent fuel at LACBWR continues to be stored in the spent fuel pool inside the reactor building. Until the fuel assemblies are removed, Dairyland must continue the NRC-required staffing of LACBWR to maintain and monitor the wet pool systems as well as required security. Dairyland also cannot fully decommission the facility and site while the fuel remains in the pool. It currently costs Dairyland approximately $5 million dollars a year for security, maintenance, and monitoring of LACBWR.

5. Although the current method for storing the fuel is safe, the fuel storage pool was not intended for long-term storage. Dairyland is currently working with contractors to plan and construct a secure dry cask storage system on the LACBWR site while awaiting the availability of a temporary or permanent centralized national repository for used nuclear fuel. This dry cask storage project involves significant costs for engineering, licensing, construction, and fuel loading. In addition, there will be ongoing security, operation and maintenance costs for a dry cask storage facility. The dry cask storage facility will enable Dairyland to reduce many of the ongoing operation and maintenance costs currently being incurred for the wet pool, even if it remains in SAFSTOR pending the beginning of the final phase of decommission of the LACBWR reactor facilities.

6. Dairyland supports a license for the Yucca Mountain high level nuclear waste repository, and desires that the NRC licensing process be completed as expeditiously as possible, consistent with the time limits established by the NWPA, in order that the Department of Energy (DOE) can begin performing its obligations to the nuclear industry. Any failure to license the project, or even a delay in licensing the project, will negatively impact Dairyland and the nuclear power industry. Such circumstances would increase the duration of onsite storage, with its related operational, environmental, and financial impacts, occupational radiation exposures, and security requirements.

7. There are also certain aspects of the repository design proposed by DOE and the specifications for fuel canisters that could lead to unnecessary occupational radiation exposures at the power reactor sites as well as at Yucca Mountain. Moreover, some aspects of the DOE proposed design and specifications are overly conservative, could increase the licensing uncertainty of the project, and could increase the ultimate costs of construction of the repository once it is licensed. These issues have implications for expenditures by DOE from the Nuclear Waste Fund.

8. Dairyland hereby authorizes the Nuclear Energy Institute to request a hearing on its behalf and to represent its interests in that hearing in connection with the NRC licensing of the Yucca Mountain high level waste repository.

Charles V. Sans Crainte

Charles V. Sans Crainte

Sworn to and subscribed before me this 18th day of December 2008.

Laurie A. Engen

Notary Public
La Crosse County, Wisconsin

My Commission expires: August 8, 2010

LAURIE A. ENGEN
Notary Public
State of Wisconsin

ATTACHMENT 7

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

	)	
In the Matter of	)	
	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
(High-Level Waste Repository)	)	
	)	
	)	
	)	

AFFIDAVIT OF DR. MATTHEW W. KOZAK, BRIAN GUTHERMAN, AND RICHARD A. LOFTIN IN SUPPORT OF PROPOSED CONTENTION NEI-SAFETY-01

Dr. Matthew W. Kozak ("MK"), Brian Gutherman ("BG"), and Richard A. Loftin ("RL"), being duly sworn, state as follows:

1. Introduction

1.1 Dr. Matthew W. Kozak

1. (MK) I am a Principal Consultant of Monitor Scientific LLC, Denver, Colorado. My statement of professional qualifications is included with the NEI Petition at Attachment 16.

2. (MK) Monitor Scientific LLC is under contract to the Nuclear Energy Institute ("NEI") to assist NEI in developing contentions, including NEI-SAFETY-01, "Spent Nuclear Fuel Direct Disposal in Dual Purpose Canisters," for its intervention petition for the construction authorization licensing proceeding for the proposed high-level waste ("HLW") repository at Yucca Mountain, NV pending before the Nuclear Regulatory Commission ("NRC" or "Commission").

3. (MK) I have a Bachelor's degree in chemical engineering from Cleveland State University, and a Ph.D. in chemical engineering from the University of Washington. I have been

involved professionally in radioactive waste management and disposal assessment, technology, and regulatory policy for more than 19 years, including more than 10 years of work on the safety of the proposed repository at Yucca Mountain.

4. (MK) I participate in a project for the Electric Power Research Institute's ("EPRI") oversight of post-closure safety for the proposed repository at Yucca Mountain, and have been associated with EPRI's program for more than 10 years.

5. (MK) I am co-author of EPRI's independent total system performance assessment reports on Yucca Mountain, including EPRI's post-closure safety assessment code, formally called the Integrated Multiple Assumptions and Release Code ("IMARC"). I have also co-authored several EPRI studies on the performance of the Yucca Mountain repository.

6. (MK) I am the former chair of Subcommittee 87-3 on Performance Assessment for the National Council on Radiation Protection and Measurements ("NCRP"). I am also a past member of NCRP Umbrella Scientific Committee 87 on Radioactive and Mixed Waste, and a past member of the National Research Council Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site.

7. (MK) I am a frequent consultant to the International Atomic Energy Agency ("IAEA"), and have supported the governments of Belarus, Bulgaria, Egypt, Estonia, Malaysia, Moldova, Poland, Romania, and the Russian Federation on IAEA missions to site, develop, construct, and analyze disposal facilities to provide national capacity to dispose of radioactive waste. In 2004, I was a member of the IAEA's International Peer Review Team for the Australian National Repository.

8. (MK) I have conducted recent project work on radioactive waste safety in Korea, Japan, Malaysia, South Africa, and Sweden. In the United States, I have supported the Environmental Protection Agency ("EPA"), EPRI, the Department of Energy ("DOE"), and NRC on a wide variety of radioactive waste disposal and radioactive contamination issues.

9. (MK) I am familiar with the regulatory concept of ALARA, where licensees implement procedures and engineering controls based upon sound radiation protection principles to achieve occupational radiation doses and doses to members of the public that are "as low as is reasonably achievable."

1.2 Brian Gutherman

10. (BG) I am Vice President of Advanced Concepts, Inc. ("ACI") of Scottsdale, Arizona. My statement of professional qualifications is included with the NEI Petition at Attachment 17.

11. (BG) ACI is under contract to the Nuclear Energy Institute ("NEI") to assist NEI in developing contentions, including NEI-SAFETY-01, "Spent Nuclear Fuel Direct Disposal in Dual Purpose Canisters," for its intervention petition for the construction authorization licensing proceeding for the proposed high-level waste repository at Yucca Mountain, Nevada pending before the NRC.

12. (BG) I earned a Bachelor of Science degree in Mechanical Engineering from Rutgers University in 1982, graduating with high honors. I have been involved professionally in nuclear power plant design, licensing, operation, and regulatory policy for more than 26 years, the last ten of which have focused on commercial spent nuclear fuel ("SNF") storage and transportation.

13. (BG) I serve as President of ACI Nuclear Energy Solutions, a New Jersey-based division of ACI with responsibility for the company's spent fuel management consulting business. I have been working in this capacity for ACI for two years.

14. (BG) I assist nuclear power plant owners in implementing dry spent fuel storage at onsite Independent Spent Fuel Storage Installations ("ISFSIs"); perform third-party assessments of ISFSI operations; and provide spent fuel management consulting services to NEI.

15. (BG) From 2004 to 2006, I worked as a private consultant in the nuclear energy field with a focus on ISFSI implementation, spent fuel management, and spent fuel storage and transportation cask licensing.

16. (BG) From 1998 to 2004, I was the licensing manager for Holtec International, a spent fuel storage and transportation cask designer. I was responsible for managing the company's efforts to acquire and amend NRC 10 C.F.R. Part 71 and 10 C.F.R. Part 72 certificates of compliance for its spent fuel cask product line.

17. (BG) In my capacity as a consultant to NEI, I track the storage of commercial SNF in the United States, including the brand of storage system technology used by the fuel owners and whether these systems are licensed for storage under 10 C.F.R. Part 72, transportation under 10 C.F.R. Part 71, or both. I track the quantity of commercial SNF stored in spent fuel pools and in ISFSIs on each site and in each state. I estimate how much commercial SNF is permanently discharged from each reactor every year, and predict future trends for dry SNF storage. I monitor the licensing status of domestic SNF storage and transportation casks, including initial certifications and amendments thereto.

18. (BG) I have reviewed and am familiar with DOE's Transport, Aging, and Disposal ("TAD") canister specification.

19. (BG) I am familiar with the regulatory concept of ALARA, where licensees implement procedures and engineering controls based upon sound radiation protection principles to achieve occupational radiation doses and doses to members of the public that are "as low as is reasonably achievable." The ALARA concept is further clarified in NRC Regulatory Guide 8.8, with which I am familiar.

1.3 <u>Richard A. Loftin</u>

20. (RL) I am a Senior Engineer, Nuclear Fuel Services, for Southern Nuclear Operating Company, Inc. My statement of professional qualifications is included with the NEI Petition at Attachment 18.

21. (RL) I earned a Bachelor of Science degree in Nuclear Engineering from Mississippi State University in 1974, and have conducted post-graduate work in Mechanical Engineering at the University of Alabama, Birmingham. I have been involved professionally in nuclear power plant design, licensing, construction, engineering, and operation, for more than 30 years, the last eleven of which have focused on commercial spent nuclear fuel ("SNF") storage and related issues. In my current position, I provide support to three nuclear plant sites (a total of six reactor units) for fuel inspections of new and spent nuclear fuel, and dry cask loading. My prior experience includes work offloading spent fuel from a reactor core, fuel shuffle within a reactor core, and reloading new nuclear fuel into reactor cores. I am currently the primary contact and interface at Southern Nuclear Operating Co. with all fuel vendors for site inspection services, other Southern personnel, and industry peers for all nuclear fuel related issues and

questions and participate on industry committees that concern spent nuclear fuel dry storage issues and casks, and the proposed geologic repository at Yucca Mountain. Based on my many years of experience with spent nuclear fuel related issues, I am very familiar with the spent nuclear fuel dry cask loading and unloading processes and the radiation exposures that result from such activities.

22. (RL) I am familiar with the regulatory concept of ALARA, where licensees implement procedures and engineering controls based upon sound radiation protection principles to achieve occupational radiation doses and doses to members of the public that are "as low as is reasonably achievable."

2. <u>NEI Contention NEI-SAFETY-01</u>

23. (MK, BG, RL) We are familiar with the license application ("LA"), including the safety analysis report ("SAR"), filed on June 3, 2008 by DOE for the proposed HLW geologic repository at Yucca Mountain, NV.

24. (MK, BG, RL) We have drafted this Affidavit in support of Proposed Contention NEI-SAFETY-01, "Spent Nuclear Fuel Direct Disposal in Dual Purpose Canisters," which reads:

> The License Application ("LA") fails to permit direct disposal of dual purpose canisters ("DPCs") containing commercial spent nuclear fuel and is therefore inconsistent with "as low as is reasonably achievable" ("ALARA") principles, unnecessarily generates additional low-level radioactive waste ("LLRW"), and wastes limited resources.

The basis for Contention NEI-SAFETY-01 reads:

> The LA states that all commercial spent nuclear fuel ("SNF") will be loaded into Transportation, Aging, and Disposal ("TAD") canisters for disposal, which means that SNF loaded into DPCs will need to be unloaded and then reloaded into TAD canisters prior to disposal, whether that unloading and reloading occur at Yucca

> Mountain or at reactor sites. The number of DPCs that would have to be unloaded and then reloaded ranges from at least 1,029 to 2,155 DPCs by the time Yucca Mountain is scheduled to open in 2020. Because the SNF-filled DPCs can be directly disposed while meeting the requirements of 10 C.F.R. Part 63, workers (whether at Yucca Mountain or reactor sites) will be unnecessarily exposed to increased radiation as a result of unloading and reloading these DPCs. In addition, the discarded DPCs will be unnecessary LLRW, and the unloading and reloading processes will result in increased resource use and costs.

25. (MK, BG, RL) This Affidavit provides the factual and technical bases supporting proposed Contention NEI-SAFETY-01. We will demonstrate that, in order to be consistent with the principles of ALARA, DOE should amend the LA to permit direct disposal of DPCs.

3. Statutory and Regulatory Background

26. (MK, BG, RL) We are aware that the Commission's regulations at 10 C.F.R. § 50.40 provide, in part, that reactor licensees must comply with 10 C.F.R. Part 20. We are also aware that the Commission's regulations at 10 C.F.R. § 63.111 provide, in part, that the geologic repository operations area must met the requirements of 10 C.F.R. Part 20. We are also aware that the Commission's regulations at 10 C.F.R. § 20.1002 provide that the regulations in Part 20 apply to persons holding NRC licenses under 10 C.F.R. Part 50 and 10 C.F.R. Part 63.

27. (MK, BG, RL) 10 C.F.R. § 20.1101(b) states that "licensee[s] shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA)." The Commission's regulations at 10 C.F.R. § 20.1003 define "ALARA" as "making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to

benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest."

28. (BG) NRC Regulatory Guide 8.8 provides further guidance on the precepts and implementation of the ALARA philosophy in the design and operation of facilities involving radioactive material.

4. Summary of LA Provisions Regarding Direct Disposal of DPCs

29. (MK, BG, RL) LA SAR Section 1.5, Waste Form and Waste Package, at p. 1.5-1, states: "[s]ome of the commercial SNF may also be sent to the repository as uncanistered SNF in a cask or in a dual-purpose canister. This commercial SNF will be removed from the cask or dual-purpose canister and placed in the TAD canister at the repository before it is placed into a waste package."

30. (MK, BG, RL) LA SAR Section 1.5.1, Characteristics of Spent Nuclear Fuel and High-Level Radioactive Waste, at p. 1.5.1-2, states: "[c]ommercial SNF that is received in dual-purpose canisters (DPCs) or as uncanistered SNF in a transportation cask is placed into a transportation, aging, and disposal (TAD) canister before being placed into an aging overpack for aging or into waste packages for disposal (BSC 2008a)."

31. (MK, BG, RL) LA SAR Section 1.5.1.1, Commercial SNF, at p. 1.5.1-8, states: "[c]ommercial SNF assemblies shipped in a cask or DPC, once received at the repository, may be either loaded into an aging overpack and sent to the aging pad or opened and transferred into a TAD canister before being placed into a waste package."

32. (MK, BG, RL) LA SAR Section 1.5.1.1.1.2.1.2, Dual-Purpose Canisters, at p. 1.5.1-12, states: "[c]urrently licensed DPCs have not been shown to be suitable for disposal purposes. However, although not currently acceptable under the provisions of 10 C.F.R. Part 961, the DOE may choose to receive DPCs at the repository and repackage the commercial SNF into a TAD canister for disposal after the execution of mutually agreeable amendments to the utilities disposal contract. Further, the DPC may be placed on the aging pad, within a properly designed overpack, while it awaits transfer of its contents or to cool the SNF. Accordingly, a brief description of DPCs is included as a discussion of canisters that may be received at the repository."

5. At Least 1,029 DPCs Will Be Loaded with SNF by The Expected Opening Date of Yucca Mountain

33. (BG) As of June 2008, 6,156 metric tons of heavy metal ("MTHM") of commercial SNF are stored in 545 DPCs at ISFSIs around the United States that are licensed for transportation under 10 C.F.R. Part 71. MTHM includes metric tons of uranium ("MTU") found in uranium oxide-based SNF and other MTU of heavy metals found in SNF and high-level waste. MTHM is used here for consistency with the Nuclear Waste Policy Act, and the Yucca Mountain LA and Final Supplemental Environmental Impact Statement ("FSEIS").

34. (BG) As of June 2008, at least 1,535 MTHM of commercial SNF are stored at ISFSIs in 131 transportation-capable DPCs that I anticipate will be licensed for transportation under 10 C.F.R. Part 71 between now and the expected opening of the repository, which could occur as early as 2020.

35. (BG) Thus, there are a total of at least 7,691 MTHM commercial SNF stored in 676 DPCs at U.S. ISFSIs at this time.

36. (BG) I expect that reactor sites will continue to load SNF into the storage technology that they currently employ (i.e., DPCs, non-transportable canisters, and bare fuel casks) prior to the availability of DOE's TAD canister system and prior to the opening of any HLW repository.

37. (BG) As TAD canisters are not yet commercially available, I have assumed, based on the current schedule for TAD canister development, that some DPCs will continue to be loaded at reactor sites at least through the end of 2012, during which year I estimate that TAD canisters will be licensed for storage and transportation of SNF under 10 C.F.R. Part 72 and 10 C.F.R. Part 71, respectively. I assume that TADs will be available for the reactor sites beginning in 2013.

38. (BG) Based on the last three years of actual data, I estimate that an amount of SNF equal to approximately 50% of all SNF permanently discharged from reactor cores each year will go into dry storage at U.S. reactor sites. SNF that is discharged from a reactor goes into a spent nuclear fuel pool. Depending on how much room is available in the pool, some other, older SNF is moved into dry storage in order to accommodate the SNF freshly discharged from the reactor. My estimate that an amount of SNF equal to approximately 50% of SNF permanently discharged from reactor cores each year will go into dry storage at reactor sites is conservative for the purposes of this contention because I expect that the percentage will increase in the future as more plants run out of wet storage space in their spent fuel pools. In other words, I expect that even more DPCs will need to be loaded (and then reloaded into TADs under DOE's proposed action) as more plants run out of wet storage space. My conservative estimate is, therefore, the likely minimum number of DPCs that will be loaded each year. Indeed, I have read and am familiar with EPRI 2008, Feasibility of Direct Disposal of Dual Purpose Canisters

in a High-Level Waste Repository. Therein, EPRI assumes that the equivalent of approximately 77% of commercial SNF permanently discharged (1,700/2,200 MTHM) will go into ISFSI storage each year between now and 2020 (EPRI 2008, p. 2-3).

39. (BG) Under my conservative assumption that an amount of SNF approximately equal to 50% of SNF permanently discharged from reactor cores each year will go to dry storage at reactor sites, an additional 5,169 MTHM of commercial SNF will go to dry storage between July 2008 and the end of 2012.

40. (BG) Of this 5,169 MTHM commercial SNF, a certain portion will be loaded into DPCs. It is possible to realistically estimate what portion will be loaded into DPCs by first calculating how much will be loaded into non-transportable canisters and bare fuel casks through 2012. Only a few commercial nuclear plants load non-transportable canisters or bare fuel casks, including Oconee, Prairie Island, and Peach Bottom. These three plants have been operating ISFSIs since 1990, 1993, and 2000, respectively. Thus, it is reasonable to assume that their spent fuel pools contain as much fuel as desired and that the licensees move an amount of fuel from their spent fuel pools to dry storage equivalent to what they permanently discharge from the reactors during each refueling outage. Therefore, I conservatively estimate that these three plants load the equivalent of 100% of their annualized SNF discharge through 2012 into dry fuel storage – a total of 586 MTHM of SNF. I assume that these three plants will continue to load non-transportable canisters or bare fuel casks. Therefore, I estimate that these three plants will load 586 MTHM of SNF into non-transportable canisters or bare fuel casks between July 2008 and the end of 2012.

41. (BG) Accordingly, subtracting the 586 MTHM of SNF to be loaded into non-transportable canisters or bare fuel casks between July 2008 and the end of 2012 from the 5,169 MTHM of total fuel going into dry storage between July 2008 and the end of 2012 yields 4,583 MTHM of fuel placed into DPCs at reactor site ISFSIs between July 2008 and the end of 2012. This estimate is a conservatively low estimate of total future, transportable DPCs that will be loaded by the industry through 2012.

42. (BG) A current-day DPC design accommodates, on average, 13 MTHM of commercial SNF. This value varies between Pressurized Water Reactor ("PWR") and Boiling Water Reactor ("BWR") fuel and the fuel assembly capacity of the DPC, but this is a reasonable average across all DPC designs. Therefore, I estimate that 353 DPCs will be loaded with SNF between July 2008 and the end of 2012, and that a total of 1,029 DPCs (676 current plus 353 future) will be loaded and in ISFSI storage in the United States at the end of 2012.

43. (BG) My estimate that 1,029 DPCs will be loaded is conservative for the purposes of this contention, in that it is likely that more DPCs will be loaded and subsequently reloaded under DOE's TAD canister program. Should the availability of TAD canisters be delayed beyond the end of 2012, utilities will continue to load DPCs. Indeed, I estimate that for each year the TAD program is delayed, an additional 75 DPCs will be loaded annually, based on the spent fuel that is discharged from reactors and accounting for the portion of that spent fuel that will likely be stored in non-transportable canisters or bare fuel casks.

44. (BG) In summary, I estimate that there will be at least 1,029 DPCs loaded with SNF at reactor sites by the end of 2012. This number is a conservative estimate and could increase depending on variables such as the amount of SNF discharged from reactors and placed

into dry storage, when TAD canisters become available, and if Oconee, Prairie Island and/or Peach Bottom change fuel storage technologies to DPCs. Indeed, I have read and am familiar with EPRI 2008, Feasibility of Direct Disposal of Dual Purpose Canisters in a High-Level Waste Repository. Therein, EPRI estimates, based on a different set of assumptions, that there will be 2,155 DPCs loaded with commercial SNF at reactor sites by 2020. EPRI 2008 at p.2-4.

6. Under DOE's Plan, The SNF in The 1,029 DPCs Will Have to be Unloaded and Reloaded into TADs

45. (BG) As summarized above, the LA states in multiple sections that all commercial SNF will be disposed of in TAD canisters inside a waste package. See LA Sections 1.5, 1.5.1, 1.5.1.1, and 1.5.1.1.1.2.1.2.

46. (BG) Because the LA requires that SNF be disposed of in TAD canisters, all of the SNF currently loaded in DPCs and that will be loaded into DPCs prior to the availability of TAD canisters will have to be unloaded from the DPCs and reloaded into TAD canisters prior to disposal.

47. (RL) Multiple additional steps are required to unload SNF from a single DPC at a reactor site and reload the SNF into TAD canisters instead of loading the DPC directly into the transport overpack. These steps include:

- Transport DPC (inside either the storage cask or a transfer cask) from the ISFSI to the Fuel Building;
- Lift and move the DPC inside a transfer cask from Fuel Building truck bay to canister preparation area;
- Remove DPC outer cover plate or closure ring and port cover welds;
- Re-flood DPC with water;

- Remove DPC inner cover plate or lid welds;
- Lift and move DPC and transfer cask to the spent fuel pool;
- Remove DPC shield plug or lid;
- Remove fuel assemblies from the DPC and place in wet storage racks;
- Lift and remove empty DPC/transfer cask assemblage from spent fuel pool;
- Lift and remove DPC from transfer cask and place DPC in designated location;
- Place transfer cask in designated location;
- Insert empty TAD canister into transport overpack;
- Lift and move TAD canister and transport overpack to spent fuel pool;
- Move SNF from wet storage racks into TAD canister;
- Install TAD canister lid;
- Lift and remove TAD canister and transport overpack from spent fuel pool and move to canister preparation area;
- Weld TAD canister inner cover plate/lid;
- Drain water from TAD canister, dry, backfill with helium, and leak test; and
- Weld TAD port covers and outer cover plate or lid
- Dispose of or recycle used DPC.

48. (BG) Steps similar to those listed above would be required to remove SNF from a DPC and reload it into TAD canisters at Yucca Mountain at the proposed repository's Wet Handling Facility. Section 2.1.1, p. 2-8, of the FSEIS states in part: "DOE would remove the spent nuclear fuel assemblies from the dual-purpose canister and place them in a TAD canister before placement in a waste package. The opened canister would be recycled or disposed of off the site as low-level radioactive waste." In addition, Section 2.1.2.1.4, p.2-22, of the FSEIS

states: "[T]the spent nuclear fuel in the [DPCs] would be repackaged into TAD canisters at the Wet Handling Facility [("WHF")]."

7. <u>Workers Will Incur Radiological Dose, and Low-Level Radioactive Waste Will Result, from Repackaging SNF from DPCs into TAD Canisters</u>

49. (BG) FSEIS Section G.1.2, at p. G-2 & G-3, addresses radiological impacts to reactor site workers involved in loading spent nuclear fuel into TAD canisters. DOE estimates the radiation dose to be 0.400 person-rem per TAD canister loaded at reactor sites. <u>See</u> FSEIS Appendix G, Table G-2, at p. G-3. This dose estimate is reasonable based on my experience. The FSEIS does not provide a separate radiation dose for loading SNF into TAD canisters at the repository's Wet Handling Facility. <u>See</u> FSEIS Table D-9 and p. D-21. In my opinion, the radiation dose to load a TAD canister at the WHF would be comparable to the 0.400 person-rem exposure per TAD canister loaded at reactor sites. This means that for every TAD canister loaded – whether at a reactor site or at the repository Wet Handling Facility – 0.400 person-rem of radiation dose will be incurred.

50. (RL) Based on my experience as Senior Engineer for Southern Nuclear Operating Company, Inc., I agree that DOE's radiation dose estimate of 0.400 person-rem per TAD canister loaded at reactor sites is reasonable. I also agree with Mr. Gutherman's opinion that the radiation dose received to load a TAD canister at the repository would be comparable to the radiation dose received to load a TAD canister at reactor sites.

51. (BG) When considering the SNF that is currently stored in DPCs, or will be stored in DPCs in advance of the implementation of the TAD program, the total dose incurred for unloading a DPC and loading that SNF into a TAD canister will be greater than the DOE-estimated dose to load the TAD because dose will also be incurred from unloading SNF from a

DPC. Indeed, the dose incurred from unloading a DPC is likely to approach or exceed (due to higher capacity) the dose incurred from loading a TAD. However, I have conservatively assumed, for the purposes of this contention, that DPCs and TADs have the same capacity.

52. (RL) Based on my experience, I agree with Mr. Gutherman's opinion that radiation dose will be incurred from unloading SNF from a DPC, and agree that the radiation dose incurred from unloading a DPC is likely to approach or exceed (due to higher capacity) the dose incurred from loading a TAD.

53. (BG) Using this conservative assumption, unloading 1,029 DPCs and loading the fuel into an equal number of TAD canisters would result in approximately 822 person-rem of radiation exposure. This total results from the following calculations: (1) 1,029 DPCs x 0.400 person-rem = 411 person-rem for unloading SNF from DPCs; (2) 411 person-rem would result from loading that SNF into TAD canisters; and (3) 411 person-rem from unloading + 411 person-rem from loading = 822 person-rem total. This dose to reactor and site workers could be avoided were DOE to directly dispose of DPCs in the Yucca Mountain repository.

54. (BG, RL) Unloading DPCs would also result in the discarded DPCs becoming low-level radioactive waste ("LLRW"), which would require processing, handling, and disposal or recycling. See FSEIS at Section 2.1.2.3.4. The additional radiological exposure to perform these activities has not been estimated, but it would not be zero.

8. Repacking SNF from DPCs into TADs Does Not Make Economic Sense

55. (BG) Under DOE's plan, additional resources (including materials, time, labor, and money) would have to be expended to repackage SNF currently stored in DPCs into TADs. Reactors will have to unload and reload SNF, and Yucca Mountain will have to unload and

reload SNF. In addition, utilities will have to purchase TADs, which are estimated to cost at least $650,000 each, based on current DPC costs, and the money invested in DPCs would be lost because the DPCs will have to be discarded. In addition, utilities will have to pay for LLRW disposal of the discarded DPCs.

9. Yucca Mountain's Current Design Can Accommodate DPC Direct Disposal

9.1 DPC Direct Disposal Would Result in No Significant Effects on Pre-closure Performance

56. (BG) DOE has addressed in the LA the pre-closure, pre-emplacement safety of DPCs by concluding that DPCs are allowed to be received and aged at the site. LA Section 1.5.1.1.1.2.1.2, at p. 1.5.1-12, states: "DOE may choose to receive DPCs at the repository and repackage the commercial SNF into a TAD canister for disposal . . . . Further, the DPC may be placed on the aging pad, within a properly designed overpack, while it awaits transfer of its contents or to cool the SNF." I agree with this conclusion. In addition, planned facilities at the repository are designed to handle the DPCs that DOE already expects to receive. Thus, there would be no additional pre-closure, pre-emplacement requirements or modifications to accommodate DPCs at the repository.

57. (BG) Likewise, there would be manageable additional post-emplacement, pre-closure requirements or modifications to accommodate emplacement of DPCs. One issue to consider is the thermal output of individual DPC canisters. At the time of the earliest projected repository operation of date of 2020, many DPCs will fall below the repository's thermal limit of 11.8kW because they have already been sufficiently aged, and the remainder can be aged prior to disposal.

58. (BG) Another issue to consider is the waste package. In general, DPCs will fit into the proposed waste package, or would require only some minor dimensional modifications of the waste package for certain DPCs. Once inside the waste package, there is little difference in handling a waste package containing a DPC than for a waste package containing a TAD.

59. (BG) Thus, there are no significant post-emplacement, pre-closure issues that would need to be addressed were DOE to permit direct disposal of DPCs.

9.2 DPC Direct Disposal Would Result in No Significant Effects on Post-closure Performance

9.2.1 Part 63 Post-closure Requirements

60. (MK) The repository post-closure requirements are as follows:

- 10 C.F.R. § 63.114(d) provides that the repository design must consider only events that have at least one chance in 10,000 of occurring over 10,000 years.

- 10 C.F.R. § 63.113(a) provides that the geologic repository must include multiple barriers, consisting of both natural barriers and an engineered barrier system.

- 10 C.F.R. § 63.113(b) provides that the engineered barrier system must be designed so that, working in combination with natural barriers, radiological exposures to the reasonably maximally exposed individual are within the limits specified at § 63.311 of subpart L of this part.

- 10 C.F.R. § 63.311 provides that DOE must demonstrate, using performance assessment, that there is a reasonable expectation that, for 10,000 years following disposal, the reasonably maximally exposed individual receives no more than an annual dose of 0.15 mSv (15 mrem) from releases from the undisturbed Yucca Mountain disposal system. DOE's analysis must include all potential pathways of radionuclide transport and exposure.

- EPA has issued a final rule that would require DOE to estimate peak dose as part of the assessments for both individual protection and human intrusion. DOE must then compare the results of these estimates to an annual dose limit of 1.0 millisieverts/year (100 millirem/year).

61. (MK) I am familiar with a report drafted by DOE that considered direct disposal of DPCs, which is entitled "The Potential of Using Commercial Dual Purpose Canisters for Direct Disposal," LSN #: DN2001065443, September 2003 ("OCRWM 2003"). Therein, DOE evaluated several issues that would need to be addressed to make a licensing case for DPC disposal. The draft report showed that there were no fundamental obstacles to direct DPC disposal, while identifying some elements of DOE's planned practices that might need modification to accommodate DPC disposal, and identifying administrative regulatory obstacles to implementation regarding burnup credit.

62. (MK) I am familiar with the statement in the LA (at page 1.5.1-12) that "[c]urrently licensed DPCs have not been shown to be suitable for disposal purposes." However, in 2007, DOE was requested by the Nuclear Waste Technical Review Board to develop and publish an evaluation of direct DPC disposal (NWTRB 2007). DOE has neither developed nor published such an evaluation. Therefore, DOE's main argument against direct DPC disposal is

that they have not been demonstrated to be suitable, even though such demonstration is DOE's responsibility and DOE has been requested by NWTRB to carry out such a demonstration.

63. (MK) Although DOE failed to carry out such an evaluation, EPRI has performed a Total System Performance Assessment ("TSPA") that evaluated direct DPC disposal. The results were published by EPRI in a report entitled "Feasibility of Direct Disposal of Dual-Purpose Canisters in a High-Level Waste Repository," EPRI Report No. 1018051, August 2008 (EPRI 2008), and concluded that some currently licensed DPCs are suitable for disposal.

64. (MK) In EPRI 2008, EPRI selected a representative design-basis DPC based on physical dimensions, construction, and capacity to envelope a range of DPC designs in use at commercial nuclear facilities. The DPC design chosen was significantly larger than the DOE's standardized TAD canister. EPRI then examined direct disposal of the design-basis DPC to determine if there would be any significant technical barriers associated with thermal effects, thermal-mechanical effects, corrosion, or overall total system performance under nominal and alternative scenarios.

65. (MK) EPRI's analyses "indicate only minor differences in performance of DPCs in the post-closure period compared to performance of TAD canisters. EPRI therefore concludes that there are no technical obstacles associated with the post-closure period that would categorically rule out direct disposal of all DPCs at Yucca Mountain."

66. (MK) For operational considerations, EPRI concluded that direct disposal of DPCs would require fabrication of disposal overpacks with slightly different dimensions than for a TAD, and design of handling equipment to accommodate these overpacks. However, EPRI

concluded that the external physical dimensions of the DPCs are similar to those of the TADs, and accommodations to permit DPC disposal should be minor. See EPRI 2008, page 2-1.

67. (MK) For thermal considerations, EPRI performed "a detailed analysis that was undertaken using conservative assumptions indicat[ing] that there is no significant thermohydrological impact even if the whole repository is emplaced with DPC waste packages, with a 50 percent higher heat generation rate than the current proposed approach employing only TADs." EPRI 2008 at p. 3-13. EPRI also noted that "[f]or the potentially more realistic case in which there would be a mixture of DPCs and TADs that would be disposed (2100 DPCs and 5010 TADs), no DOE-imposed temperature or pillar dry-out criterion is violated." EPRI 2008 at p. 3-13. EPRI also stated that "[i]t is noteworthy that OCRWM (2003) concluded that thermal management issues could be addressed simply by managing the duration of onsite storage." EPRI 2008 at 3-1.

68. (MK) For thermal-mechanical considerations, EPRI concluded that thermal-mechanical factors do not present significant obstacles to direct DPC disposal at Yucca Mountain. EPRI 2008 at 4-8. Temperatures evaluated were for the bounding assumption that all waste packages in the repository carry the heat load associated with DPCs, without any other thermal management strategy, as well as for a more reasonable assumed value of 2100 DPCs. See EPRI 2008 at 3-9 to 3-11. Even under these conditions, thermal-mechanical considerations do not pose an impediment for repository management. For the more likely conditions of mixed DPC and TAD disposal, the effects are even smaller.

69. (MK) For corrosion considerations, EPRI concluded that corrosion of the Alloy 22 disposal overpack would be identical for both DPC and TAD disposal. EPRI 2008 at p. 5-1.

Temperatures do not rise sufficiently high to affect the potential for localized corrosion, even for the bounding assumption that all waste packages in the repository carry the heat load associated with DPCs, without any other thermal management strategy. EPRI 2008 at p. 5-1.

70. (MK) For TSPA analyses, EPRI concluded that only very minor differences exist between DPC disposal and TAD disposal for a variety of scenarios, assumptions, and sensitivity analyses. EPRI 2008 at p. 8-1. The comparison between TAD disposal and DPC disposal for the nominal scenario is shown in Figure 1 below. Evaluations were conducted for the nominal scenario, for the credible alternative scenarios of volcanism and seismic disruption, and for a scenario that has been screened from TSPA because of low probability: the criticality scenario. In all analyses, both DPC disposal and TAD disposal demonstrated acceptable post-closure performance.

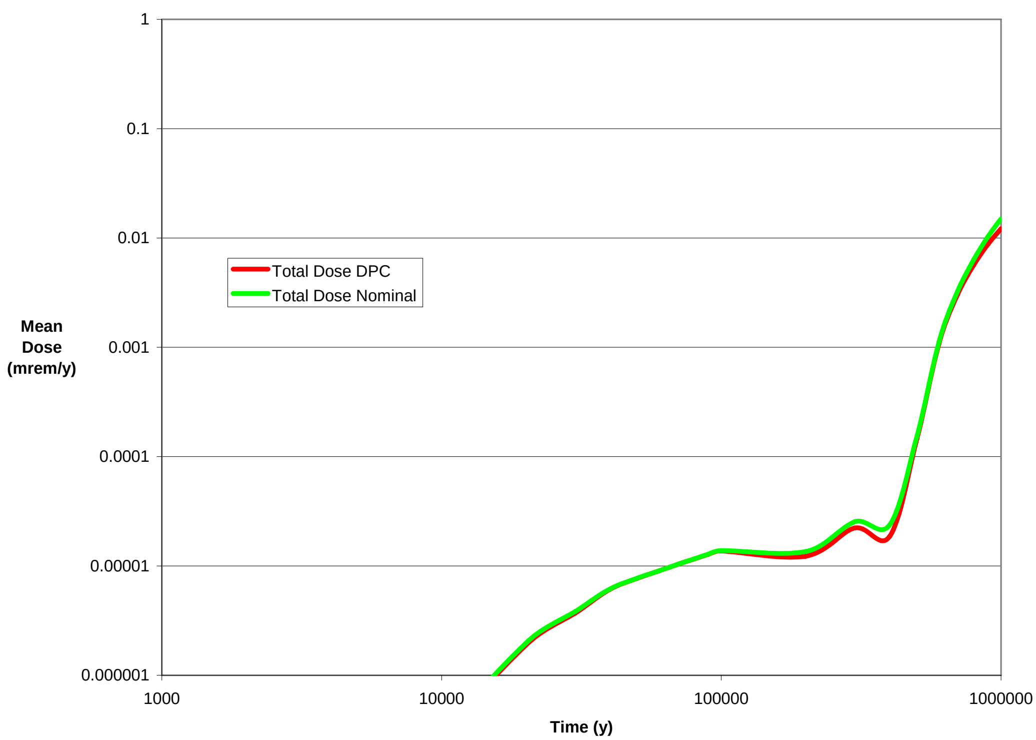

Figure 1. Comparison between the disposal of a 21-PWR waste package with a TAD disposal overpack and DPC disposal, assuming 100 percent of the waste packages are DPCs. (EPRI, 2008a, Figure 19, page 6-2).

10. **Conclusion**

71. (MK, BG, RL) DOE's plan to forgo disposal of SNF in the DPCs in which that SNF is stored and instead to unload the DPCs and reload the SNF into TAD canisters does not comport with the requirements of 10 C.F.R. Part 20 because the decision to unnecessarily repackage is inconsistent with ALARA principles. The proposed Yucca Mountain repository will meet pre-closure and post-closure performance requirements with the direct disposal of SNF in DPCs. The unloading and reloading of SNF from DPCs into TADs will result in (1) unnecessary radiological exposure to reactor site and repository site workers; (2) an unnecessary stream of LLRW; and (3) unnecessary increased resource use and costs. Therefore, DOE should amend the LA to permit direct disposal of SNF in DPCs.

Matthew Kozak

Sworn and subscribed to before me this 15th day of December 2008.

Jennifer R. Chance
Notary Public
State of Colorado
My Comm. Expires 1/25/2010

Jennifer R Chance
Notary Public
My Commission expires: 1/25/2010

Brian Gutherman

Sworn and subscribed to before me this 13th day of December 2008.

MEREDITH PEASE EASTERLY
NOTARY PUBLIC
STATE OF NEW JERSEY
MY COMMISSION EXPIRES AUGUST 17, 2011

Meredith Pease Easterly
Notary Public
My Commission expires: 8-17-11

Richard Loftin

Sworn and subscribed to before me this 15th day of December 2008.

Gail A. Hicks
Notary Public Gail A. Hicks
My Commission expires: July 5, 2010

STATE OF Alabama
COUNTY OF Jefferson
Commissioned in Bibb County

References

EPRI 2008. *Feasibility of Direct Disposal of Dual-Purpose Canisters in a High-Level Waste Repository*. EPRI Report No. 1018051, August 2008. LSN Accession No. NEN000000722.

NWTRB 2007. Nuclear Waste Technical Review Board, letter dated April 19, 2007. LSN Accession No. NEV000003407.

OCRWM 2003. *The Potential of Using Commercial Dual Purpose Canisters for Direct Disposal*. Draft Report TDR-CRW-SE-000030 REV 00. Office of Civilian Radioactive Waste Management, Washington DC. LSN Accession No. DN2001065443.

ATTACHMENT 8

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
(High-Level Waste Repository)	)	

AFFIDAVIT OF BRIAN GUTHERMAN AND RICHARD A. LOFTIN IN SUPPORT OF PROPOSED CONTENTION NEI-SAFETY-02

Brian Gutherman ("BG") and Richard A. Loftin ("RL"), being duly sworn, state as follows:

1. Introduction

1.1 Brian Gutherman

1. (BG) I am Vice President of Advanced Concepts, Inc. ("ACI") of Scottsdale, Arizona. My statement of professional qualifications is included with the NEI Petition at Attachment 17.

2. (BG) ACI is under contract to the Nuclear Energy Institute ("NEI") to assist NEI in developing contentions, including NEI-SAFETY-02, "Insufficient Number of Non-TAD SNF Shipments to Yucca Mountain," for its intervention petition for the construction authorization licensing proceeding for the proposed high-level waste repository at Yucca Mountain, Nevada pending before the Nuclear Regulatory Commission ("NRC" or "Commission").

3. (BG) I earned a Bachelor of Science degree in Mechanical Engineering from Rutgers University in 1982, graduating with high honors. I have been involved professionally in

nuclear power plant design, licensing, operation, and regulatory policy for more than 26 years, the last ten of which have focused on commercial spent nuclear fuel (“SNF”) storage and transportation.

4. (BG) I serve as President of ACI Nuclear Energy Solutions; a New Jersey-based division of ACI with responsibility for the company’s spent fuel management consulting business. I have been working in this capacity for ACI for two years.

5. (BG) I assist nuclear power plant owners in implementing dry spent fuel storage at onsite Independent Spent Fuel Storage Installations (“ISFSIs”); perform third-party assessments of ISFSI operations; and provide spent fuel management consulting services to NEI.

6. (BG) From 2004 to 2006, I worked as a private consultant in the nuclear energy field with a focus on ISFSI implementation, spent fuel management, and spent fuel storage and transportation cask licensing.

7. (BG) From 1998 to 2004, I was the licensing manager for Holtec International, a spent fuel storage and transportation cask designer. I was responsible for managing the company’s efforts to acquire and amend NRC 10 C.F.R. Part 71 and 10 C.F.R. Part 72 certificates of compliance for their spent fuel cask product line.

8. (BG) In my capacity as a consultant to NEI, I track the storage of commercial SNF in the United States, including the brand of storage system technology used by the fuel owners and whether these systems are licensed for storage under 10 C.F.R. Part 72, transportation under 10 C.F.R. Part 71, or both. I track the quantity of commercial SNF stored in spent fuel pools and in ISFSIs on each site and in each state. I estimate how much commercial

SNF is permanently discharged from each reactor every year, and predict future trends for dry SNF storage. I monitor the licensing status of domestic SNF storage and transportation casks, including initial certifications and amendments thereto.

9. (BG) I have reviewed and am familiar with the Department of Energy's ("DOE") Transport, Aging, and Disposal ("TAD") canister specification.

10. (BG) I am familiar with the regulatory concept of ALARA, where licensees implement procedures and engineering controls based upon sound radiation protection principles to achieve occupational radiation doses and doses to members of the public that are "as low as is reasonably achievable." The ALARA concept is further clarified in NRC Regulatory Guide 8.8, with which I am familiar.

1.2 <u>Richard A. Loftin</u>

11. (RL) I am a Senior Engineer, Nuclear Fuel Services, for Southern Nuclear Operating Company, Inc. My statement of professional qualifications is included with the NEI Petition at Attachment 18.

12. (RL) I earned a Bachelor of Science degree in Nuclear Engineering from Mississippi State University in 1974, and have conducted post-graduate work in Mechanical Engineering at the University of Alabama, Birmingham. I have been involved professionally in nuclear power plant design, licensing, construction, engineering, and operation, for more than 30 years, the last eleven of which have focused on commercial spent nuclear fuel ("SNF") storage and related issues. In my current position, I provide support to three nuclear plant sites (a total of six reactor units) for fuel inspections of new and spent nuclear fuel, and dry cask loading. My prior experience includes work offloading spent fuel from a reactor core, fuel shuffle within a

reactor core, and reloading new nuclear fuel into reactor cores. I am currently the primary contact and interface at Southern Nuclear Operating Co. with all fuel vendors for site inspection services, other Southern personnel, and industry peers for all nuclear fuel related issues and questions and participate on industry committees that concern spent nuclear fuel dry storage issues and casks, and the proposed geologic repository at Yucca Mountain. Based on my many years of experience with spent nuclear fuel related issues, I am very familiar with the spent nuclear fuel dry cask loading and unloading processes and the radiation exposures that result from such activities.

13. (RL) I am familiar with the regulatory concept of ALARA, where licensees implement procedures and engineering controls based upon sound radiation protection principles to achieve occupational radiation doses and doses to members of the public that are "as low as is reasonably achievable."

2. <u>NEI Contention NEI-SAFETY-02</u>

14. (BG, RL) We are familiar with the license application ("LA"), including the safety analysis report ("SAR"), filed on June 3, 2008 by DOE for the proposed HLW geologic repository at Yucca Mountain, NV, and the accompanying Final Supplemental Environmental Impact Statement ("FSEIS").

15. (BG, RL) We have drafted this Affidavit in support of proposed Contention NEI-SAFETY-02, "Insufficient Number of Non-TAD SNF Shipments to Yucca Mountain," which reads:

> Yucca Mountain's surface facility design capability to receive not less than 90% of commercial spent nuclear fuel ("SNF") in Transportation, Aging, and Disposal

> ("TAD") canisters is inconsistent with "as low as is reasonably achievable" ("ALARA") principles.

The basis for Contention NEI-SAFETY-02 reads:

> The Yucca Mountain License Application ("LA") states that the repository surface facilities are designed to receive at least 90% of commercial spent nuclear fuel at the repository in TAD canisters (loaded at reactor sites). This will result in some commercial SNF already loaded into dual-purpose canisters ("DPCs") and transportable bare fuel casks ("BFCs") being unloaded and reloaded into TAD canisters at reactor sites instead of at the repository. This in turn will result in reactor site workers responsible for unloading the DPCs and BFCs and reloading the spent nuclear fuel into TAD canisters for transport being unnecessarily exposed to increased radiation dose, a result that can be reduced if DOE accepts up to 25% of commercial spent nuclear fuel in DPCs and transportable BFCs. DOE has analyzed the environmental impacts of an alternative scenario whereby up to 25% of SNF would be received at Yucca Mountain in non-TAD canisters and casks and concluded that there would be little if any additional environmental impacts at the repository under this scenario.

16. (BG, RL) This Affidavit provides the factual and technical bases supporting Contention NEI-SAFETY-02. We will demonstrate that, in order to be consistent with the principles of ALARA, DOE should amend the LA to design the Yucca Mountain surface facilities to receive up to 25% of SNF in DPCs and BFCs.

3. <u>Statutory and Regulatory Background</u>

17. (BG, RL) We are aware that the Commission's regulations at 10 C.F.R. § 50.40 provide, in part, that reactor licensees must comply with 10 C.F.R. Part 20. We are also aware that the Commission's regulations at 10 C.F.R. § 63.111 provide, in part, that the geologic repository operations area must met the requirements of 10 C.F.R. Part 20. We are also aware that the Commission's regulations at 10 C.F.R. § 20.1002 provide that the regulations in Part 20 apply to persons holding NRC licenses under 10 C.F.R. Part 50 and 10 C.F.R. Part 63.

18. (BG, RL) 10 C.F.R. § 20.1101(b) states that "licensee[s] shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA)." The Commission's regulations at 10 C.F.R. § 20.1003 define "ALARA" as "making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest."

19. (BG) NRC Regulatory Guide 8.8 provides additional guidance on the precepts and implementation of the ALARA philosophy in the design and operation of facilities involving radioactive material.

4. Summary of LA Provisions Regarding the Repository's Non-TAD SNF Design Capability

20. (BG, RL) LA General Information Section 1.2.2, Routine Operations, states at p. 1-16 : "The [Geologic Repository Operations Area] surface facilities have been designed to support a mostly canistered waste stream. A TAD canister is utilized for commercial SNF assemblies. The repository objective is to have 90% of individual commercial SNF assemblies loaded into TAD canisters by the utilities with a limited quantity of uncanistered individual commercial SNF assemblies and dual-purpose canisters requiring handling in a pool (i.e., submerged). In some cases, commercial SNF will require aging before it is ready for emplacement."

21. (BG, RL) LA SAR Section 1.5.1.1, Commercial SNF, at p. 1.5.1-8, states that "[t]he majority of commercial SNF assemblies will be shipped to the repository in TAD canisters. The TAD canisters are transferred directly into a waste package for disposal or into an aging overpack for aging. Commercial SNF assemblies that cannot be placed into TAD canisters at utility sites can be handled and shipped to the repository in transportation casks certified by the NRC or in DPCs. Commercial SNF assemblies shipped in a cask or DPC, once received at the repository, may be either loaded into an aging overpack and sent to the aging pad or opened and transferred into a TAD canister before being placed into a waste package . . . . In each year of operation, the repository shall be capable of accepting, transporting, and disposing of commercial SNF where at least 90% is received in TAD canisters and no more than 10% is received as uncanistered assemblies."

5. <u>DOE's Proposal Requires Some Non-TAD SNF to be Re-packaged into TAD Canisters at Reactor Sites Prior to Shipment to Yucca Mountain</u>

22. (BG) Although DOE has designed the repository surface facilities to receive at least 90% of commercial SNF in TAD canisters, more than 10% of commercial SNF is already stored in DPCs and transportable BFCs. The number of DPCs and transportable BFCs loaded at reactor sites will continue to increase until TAD canisters are available for use by the reactor operators.

23. (BG) Section 114(d) of the Nuclear Waste Policy Act, as amended, limits the first geologic repository's capacity to 70,000 metric tons of heavy metal ("MTHM") until a second repository is operational. The term MTHM includes the category metric tons of uranium ("MTU") found in uranium oxide-based SNF and other MTU of heavy metals found in SNF and

high-level waste. MTHM is used here for consistency with the Nuclear Waste Policy Act and the Yucca Mountain LA and FSEIS.

24. (BG) Section 1.4.2 of the Yucca Mountain Repository FSEIS, Proposed Approach to Disposal, states at p. 1-14, "[t]he materials DOE would dispose of under the Proposed Action include about 63,000 MTHM of commercial spent nuclear fuel and high-level radioactive waste…." The 63,000 MTHM commercial SNF amount is an estimate that takes into account the amount of DOE SNF and high level waste that also must be disposed of in the repository (see FSEIS Table 3-20, p. 3-101), while still meeting the overall 70,000 MTHM limit.

25. (BG) Thus, under DOE's proposed scenario whereby no more than 10% of commercial SNF would be received at Yucca Mountain in DPCs and transportable BFCs, no more than 6,300 MTHM can be received at Yucca Mountain in non-TAD canisters and transportable BFCs.

26. (BG) I estimate that, as of June 2008, approximately 11,721 MTHM of commercial SNF was in dry ISFSI storage in the United States. Twenty-five (25) MTHM of this fuel is stored in modular ventilated storage at the Fort St. Vrain site. Thus, approximately 11,696 MTHM of commercial SNF is in dry storage in casks or canisters as of June 2008. This amount is broken down into the following types of storage:

1. Fuel in non-transportable bare fuel casks: 293 MTHM;
2. Fuel in Part 71-licensed transportable bare fuel casks: 482 MTHM;
3. Fuel in bare fuel casks designed to be transportable, but not yet Part 71-licensed: 1,272 MTHM;
4. Fuel in non-transportable canisters: 1,957 MTHM;

5. Fuel in Part 71-licensed DPCs: 6,156 MTHM.
6. Fuel in canisters designed to be DPCs, but not yet licensed for transportation: 1,535 MTHM.

27. (BG) Thus, I estimate that 6,638 MTHM of commercial SNF is currently being stored in BFCs licensed for transportation (482 MTHM) and DPCs licensed for transportation (6,156 MTHM). This amount exceeds the 10% non-TAD SNF limitation of 6,300 MTHM of commercial SNF that DOE intends to receive at the Yucca Mountain repository in transportable BFCs and DPCs.

28. (BG) I expect that reactor sites will continue to load SNF into DPCs and transportable BFCs prior to the availability of DOE's TAD canister system and prior to the opening of a high-level waste repository at Yucca Mountain, which, if approved, is estimated to occur in 2020 at the earliest.

29. (BG) As TAD canisters are not yet commercially available, I have assumed, based on the current schedule for TAD development, that DPCs will continue to be loaded at reactor sites at least through the end of 2012, under DOE's expectation that TAD canister designs will be licensed and made available for SNF storage in 2013.

30. (BG) Based on the last three years of data, I estimate that an amount of SNF equal to approximately 50% of SNF permanently discharged from reactor cores each year will go into dry storage at reactor sites. SNF that is discharged from a reactor initially goes into a spent nuclear fuel pool. Depending on how much room is available in the pool, some other, older SNF is moved into dry storage in order to accommodate the SNF freshly discharged from the reactor. My estimate that an amount of SNF equal to approximately 50% of SNF permanently discharged

from reactor cores each year will go into dry storage at reactor sites is a conservatively low estimate because I expect that the percentage will increase in the future as more plants run out of wet storage space in their spent fuel pools. Indeed, I have read and am familiar with EPRI 2008, Feasibility of Direct Disposal of Dual Purpose Canisters in a High-Level Waste Repository, August 2008. Therein, EPRI assumes that the equivalent of approximately 77% of commercial SNF permanently discharged each year (1,700/2,200 MTHM) goes into ISFSI storage each year between now and 2020 (EPRI 2008, p. 2-3).

31. (BG) Under my assumption that an amount of SNF approximately equal to 50% of SNF permanently discharged from reactor cores each year will go into dry storage at reactor sites, an additional 5,169 MTHM of commercial SNF will go into dry storage at reactor sites between July 2008 and the end of 2012. I estimate that at least 95%, or 4,908 MTHM, of this SNF will be stored in DPCs and transportable BFCs.

32. (BG) As previously discussed, 1,272 MTHM SNF is stored in BFCs designed to be transportable, but not yet Part 71-licensed; and 1,535 MTHM SNF is stored in DPCs not yet licensed for transportation. In my opinion, it is likely that these casks and canisters will be licensed for transportation by the time of the Yucca Mountain estimated opening in 2020. Therefore, it is likely that the 2,807 MTHM (1,272 MTHM + 1,535 MTHM) stored in these casks and canisters will be able to be transported to Yucca Mountain.

33. (BG) Thus, by the time Yucca Mountain is expected to open in 2020, I estimate that at least 14,354 MTHM of commercial SNF (consisting of 6,638 MTHM currently stored in DPCs and transportable BFCs, 4,908 MTHM that will be stored in DPCs and transportable BFCs

through the end of 2012, and 2,807 MTHM stored in DPCs and BFCs that will be licensed by 2020) will reside in transport-licensed DPCs and BFCs in the United States.

34. (BG) This amount is 8,054 MTHM more than the amount of commercial SNF that DOE intends to receive at the repository in other than TAD canisters as stated in the LA – 10% or 6,300 MTHM of commercial SNF. Thus, under DOE's 90% TAD receipt strategy, at least 8,054 MTHM of commercial SNF will have to be unloaded from DPCs and transportable BFCs and re-loaded into TAD canisters at reactor sites or elsewhere before it arrives at the Yucca Mountain repository. Because I am not aware of any alternative locations for the unloading and reloading to occur, I assume that the unloading and reloading will occur at reactor sites.

35. (BG) My estimate that at least 8,054 MTHM of commercial SNF will have to be re-loaded into TAD canisters from DPCs and transportable BFCs at reactor sites is conservative. Should the availability of TAD canisters be delayed beyond 2013, utilities will continue to load DPCs and transportable BFCs. Indeed, I estimate that for each year the TAD program is delayed, an additional 1,042 MTHM SNF will be put into dry storage in DPCs and transportable BFCs (approximately, 75 DPCs and 5 BFCs) based on the SNF that is discharged from reactors and placed into dry storage, and the small portion of the SNF in dry storage that will likely be stored in non-transportable canisters/casks.

36. (BG) In summary, I estimate that there will be at least 14,354 MTHM commercial SNF loaded in DPCs and transportable BFCs at reactor sites by 2020, which exceeds DOE receipt limit by 8,054 MTHM. This number is a conservative estimate and could increase

depending on variables such as the amount of SNF discharged from reactors and placed into dry storage and when TAD canisters become available.

6. <u>No Additional Significant Environmental Impacts at the Repository Would Result from Receiving up to 25% of Commercial SNF in Non-TAD Canisters and Casks</u>

37. (BG, RL) DOE has analyzed the environmental impacts of an alternative scenario whereby up to 25% of SNF would be received at Yucca Mountain in non-TAD canisters and casks. <u>See</u> FSEIS at Appendix A, Section A.2, "Reduced Transportation Aging, and Disposal Canister Use Option." Under this alternative, DOE states that it would accommodate 25% non-TAD receipt by constructing an additional Wet Handling Facility ("WHF"), for a total of two WHFs, and constructing two rather than three Canister Receipt and Closure facilities.

38. (BG, RL) On balance, DOE concludes that there would be little if any difference in environmental impacts from the repository under this scenario. <u>See</u> FSEIS at Appendix A, Section A.2. Long term impacts and repository performance would not change. Because the number of facilities would remain the same, DOE concludes that no additional impacts to land use, air quality, biological resources, socioeconomics, noise, aesthetics, utilities, energy, and materials are expected. An additional WHF is not expected to use much additional water for the spent fuel pool that is part of a second WHF. Once the spent fuel pool is filled, it will require only minimal additional water. DOE does expect an increase in low-level radioactive waste ("LLRW") generation from the additional WHF and the requirement to dispose of discarded canisters and casks, but DOE's plan changes only the location where the LLRW is generated. There is in fact no overall increase in LLRW because, if the spent fuel is repackaged at reactor sites, the additional LLRW will occur there. DOE concludes that there would be little, if any, significant increased radiation exposures to workers or the public from an additional WHF.

DOE estimates that the risk of onsite accidents would be equal between the proposed scenario and the alternative analyzed.

39. (BG, RL) Under DOE's alternative scenario, DOE could receive up to 15,750 MTHM commercial SNF in non-TAD canisters and casks (25% of 63,000 MTHM is 15,750 MTHM). Thus, according to DOE's analysis and its conclusion that little if any significant environmental impacts would result from the 25% non-TAD receipt scenario, DOE could receive all of the commercial SNF that I estimate to exist in DPCs and transportable BFCs at the end of 2020 — 14,354 MTHM — with little or no additional significant environmental impacts at the repository.

7. <u>DOE's Non-TAD SNF Receipt Limitation is Inconsistent with ALARA Principles</u>

40. (BG) Beneficial impacts will result if repackaging operations are handled centrally rather than at reactor sites. The doses from repackaging will be greater to the extent that repackaging takes place at reactor sites rather than at Yucca Mountain. Reactor sites are not as well equipped to handle repackaging that many canisters and casks, whereas DOE is proposing to construct one WHF that is designed specifically for the repackaging of SNF from DPCs and transportable BFCs into TADs. Although doses from repackaging would be within regulatory limits regardless of where repackaging takes place, a workforce that specializes repackaging (or at least performs it on a regular basis, as would be the case at Yucca Mountain) can be expected to be more efficient at the process (and therefore accomplish it with lower dose per canister) than would a reactor site work force that carries out repackaging on a much less frequent basis.

41. (BG) The Yucca Mountain WHF is specifically designed to unload DPCs and BFCs, reload the fuel into TAD canisters, and prepare the TAD canister for aging or disposal in a waste package. LA SAR Section 1.2.5.1.1.

42. (BG) Most reactor sites were designed to load a transportation cask in the spent fuel pool, prepare that cask for shipment, and transfer the cask onto the transportation vehicle. Reactor sites have been able to adapt their facilities to periodically move fuel from the spent fuel pool to dry storage casks for deployment at an ISFSI for temporary storage until DOE removes the SNF from their sites. As discussed above, the large majority of this fuel is stored in DPCs or transportable BFCs. Frequencies of spent fuel dry storage campaigns vary from annually to several years depending on the number of reactors at the site and the plants' individual fuel management strategies.

43. (BG) Retrieving DPCs or transportable BFCs from the ISFSI, transferring the DPC into a transportation cask, and placing the transportation cask on a transport vehicle are expected operations. These operations would be relatively low-dose because the individual fuel assemblies need not be handled. However, if the 10% non-TAD fuel limit is maintained, reactor sites will need to repackage individual spent fuel assemblies currently stored in DPCs and transportable BFCs into TAD canisters at their plants rather than this activity occurring at the WHF.

44. (BG) Repackaging of individual spent fuel assemblies from DPCs and transportable BFCs will be a lower-dose operation at the Yucca Mountain WHF for two principal reasons. First, WHF facility and equipment will be specifically designed to handle DPCs and transportable BFCs, unload the fuel assemblies, and load the fuel assemblies into TAD canisters.

In particular, the WHF will be designed to accommodate both a DPC or BFC and a TAD canister in the pool at the same time. This gives repository workers the option to move the fuel assemblies directly from the re-opened DPC/BFC to the TAD canister and not have to place the assemblies in wet storage rack before they ultimately reload them into a TAD canister. LA SAR Section 1.2.5.1.2.2. Reactor sites typically do not have the room in their spent fuel pools to do this. If a DPC or BFC needs to be repackaged into a TAD canister at a reactor site, the fuel removed from the DPC/BFC will need to be placed in the wet storage racks, the DPC/BFC removed from the pool, the TAD canister inserted in the pool in its place, and the fuel moved from the wet storage racks into the TAD canister. Thus, repackaging at the WHF is a more efficient, lower-dose operation than if it was performed at the reactor sites.

45. (BG) Second, repository personnel will conduct repackaging operations regularly, presumably on a daily or weekly basis. Workers at reactor sites would perform this operation perhaps annually, at most. A staff that performs a task frequently undoubtedly will perform the task more efficiently. This also leads to repackaging at the WHF being a lower-dose operation than if it was performed at the reactor sites.

46. (RL) Based on my experience as Senior Engineer for Nuclear Fuel Services for Southern Nuclear Operating Company, Inc., I agree with Mr. Gutherman’s analysis that repackaging of spent fuel from DPCs and transportable BFCs will be a lower-dose operation at the Yucca Mountain WHF for the reasons stated: (1) the WHF will be specifically designed for the unloading and reloading processes and can accommodate the DPC/BFC simultaneously with the TAD, which will result in a more efficient and lower dose operation than if those processes were performed at reactor sites; and (2) workers that perform the unloading and reloading processes on a regular basis will perform those tasks more efficiently.

47. (BG, RL) The fact that DOE concludes that there would be no significant adverse environmental impacts from receiving up to 25% SNF at Yucca Mountain in non-TAD casks and canisters, combined with the efficiencies that would result from centralizing such operations, demonstrates that DOE's proposed plan is not consistent with ALARA principles.

8. <u>Conclusion</u>

48. (BG, RL) In order to be consistent with the principles of ALARA, DOE should amend the LA to design the Yucca Mountain surface facilities to receive up to 25% of SNF in DPCs and BFCs so that repackaging of SNF from DPCs and BFCs occurs at the repository rather than at reactor sites. Repackaging at the repository will cause lower occupational radiological exposures. In addition, DOE has generally concluded that that there will be no additional significant adverse environmental impacts at the repository from receiving up to 25% of SNF in DPCs and BFCs at the repository.

Brian Gutherman

Sworn and subscribed to before me this 13th day of December 2008.

MEREDITH PEASE EASTERLY
NOTARY PUBLIC
STATE OF NEW JERSEY
MY COMMISSION EXPIRES AUGUST 17, 2011

Notary Public
My Commission expires: 8-17-11

Richard Loftin

Sworn and subscribed to before me this 15th day of December 2008.

Notary Public Gail A. Hicks
My Commission expires: July 5, 2010

STATE OF Alabama
COUNTY OF Jefferson
Commissioned in Bibb County

References

EPRI 2008. *Feasibility of Direct Disposal of Dual-Purpose Canisters in a High-Level Waste Repository*. EPRI Report No. 1018051, August 2008. LSN Accession No. NEN000000722.

ATTACHMENT 9

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of:	)	
	)	
U.S. Department of Energy	)	Docket No. 63-001
(High Level Waste Repository	)	
	)	
	)	

AFFIDAVIT OF CHRISTOPHER W. FULLER, MICHAEL G. GRAY, AND DANIEL R.H. O'CONNELL IN SUPPORT OF PROPOSED CONTENTION NEI-SAFETY-03

Christopher W. Fuller, Michael G. Gray, and Daniel R.H. O'Connell, being duly sworn, state as follows:

1. I, Christopher W. Fuller, Ph.D., M.Sc., B.S., am a Project Geologist employed by William Lettis & Associates, Inc. of Walnut Creek, California. My advanced degree is in Geological Sciences. I have extensive experience in the fields of active tectonics and lithospheric geodynamics. My professional work has focused on seismic hazards evaluation for critical facilities nationally and internationally, including nuclear power projects. My full Statement of Professional Qualifications is Attachment 19 to the Nuclear Energy Institute (NEI) Petition to Intervene.

2. I, Michael G. Gray, M.S., P.G., C.E.G., am a Principal Engineering Geologist, also employed by William Lettis & Associates, Inc. My advanced degree is in Geological Sciences. I have over 20 years of experience with complex geological, geotechnical, and hydrogeologic studies on a wide variety of projects, including nuclear power facilities. My expertise is focused on data acquisition, characterization and interpretation of complex geologic

and hydrogeologic conditions, and geologic hazards assessments and mitigation evaluations. My full Statement of Professional Qualifications is Attachment 20 to the NEI Petition to Intervene.

3. I, Daniel R.H. O'Connell, Ph.D., M.S., B.S., am a Senior Geophysicist, also employed by William Lettis & Associates, Inc. My degrees are in Geophysics and I have 30 years experience in geophysical investigation of earthquake and flood hazards. My experience includes probabilistic and deterministic seismic hazard investigations, geophysical site characterizations for earthquake engineering, and site-specific ground motion modeling. I have provided a lead technical role within the Bureau of Reclamation seismic and flood hazards programs for more than 15 years, including development of standards and procedures for the conduct of probabilistic seismic and flood hazard studies of critical infrastructure. These included detailed seismotectonic, ground motion, and flood studies throughout the western and central United States. My full Statement of Professional Qualifications is Attachment 21 to the NEI Petition to Intervene.

4. We have been engaged by NEI to evaluate certain aspects related to seismic design of the License Application (LA) and Safety Analysis Report (SAR) submitted to the Nuclear Regulatory Commission (NRC) by the Department of Energy (DOE) for the proposed high level nuclear waste repository at Yucca Mountain, Nevada. We make this affidavit jointly, based on our review of the LA, SAR, and related reference materials, in support of proposed contention NEI-SAFETY-03.

Overview

5. Section 1.2.7.1.3.2.1 of the LA Safety Analysis Report (SAR) states that the vertical aging overpack system of the aging facility "must withstand a seismic event characterized by horizontal and vertical peak ground accelerations of 96.52 ft/s^2 (3g) without

tipover and without exceeding canister leakage rates." This design requirement will be referred to throughout this affidavit as "the 3g design requirement." We contend that the 3g design requirement is excessively conservative based on our conclusions that: (1) the design basis corresponding to a 3g ground motion at the surface facilities is significantly more conservative than the design bases used for similar and more risk-significant nuclear facilities regulated by the NRC, and (2) the seismic hazard curve used by DOE to derive the 3g design requirement over estimates the peak ground acceleration (PGA) for the aging pads on which the aging overpacks will be positioned due to excessive conservatisms within the probabilistic seismic hazard analysis (PSHA). Each of these two issues is discussed below.

1. <u>Design Basis Conservatism</u>

6. Section 1.2.2.1.6.3 of the LA SAR states that the methodology supporting the seismic design of important to safety (ITS) surface systems, structures, and components (SSCs) is presented within *Preclosure Seismic Design and Performance Demonstration Methodology for a Geologic Repository at Yucca Mountain Topical Report* (DOE, 2007). Among other topics, this report provides a detailed description and justification of the methodology used to derive the seismic design bases for the preclosure surface facilities. This report (DOE, 2007) states that the various design basis ground motion (DBGM) levels used for ITS SSCs were chosen to be consistent with NRC regulatory precedents from similar nuclear facilities (*e.g.*, DOE, (2007), Section 3.1.1.1) and that the explicit DBGM level for a particular SSC is based on a comparison of the risk significance of that SSC to those of other nuclear facilities, thus ensuring that the most risk-significant SSCs have the most severe DBGMs (*e.g.*, DOE, (2007), Section 3.1.2).

7. Regulatory precedent for DBGMs at other nuclear facilities cited by the report (DOE, 2007) include those for nuclear power plants and spent fuel storage facilities (*e.g.*,

independent spent fuel storage installation's (ISFSIs) and monitored retrievable storage (MRS) facilities). The stated purpose of comparing Yucca Mountain DBGMs to these facilities is that the risk significance of the Yucca Mountain surface ITS SSCs is comparable to that of an ISFSI (*see* DOE (2007), Section 3.1.1.1). The DOE report cites several NRC rulemakings and other precedent demonstrating NRC support of these design basis comparisons (*see* DOE (2007), Section 3.1.1.1). For the design basis of nuclear power plants, the report refers to Regulatory Guide 1.165 (NRC, 1997) in stating that the DBGM for nuclear power plants is the ground motion associated with the median annual probability of exceedance of 1 x 10^{-5}, or approximately equivalent to a mean annual probability of exceedance (MAPE) of 1 x 10^{-4} (*see* DOE (2007), Section 2.3.1).[1] For other nuclear-related facilities that are not power plants (*e.g.*, an ISFSI or MRS), the report states that the NRC has approved DBGMs with MAPE between 4 x 10^{-4} and 5 x 10^{-4} (*see* DOE (2007), Section 2.3.1 for a full discussion).

8. Given the relative risk significance of the Yucca Mountain surface facilities compared to ISFSIs and nuclear power plants, we believe it is logical and reasonable to have DBGMs for the Yucca Mountain surface ITS SSCs, including the vertical aging overpack, with MAPE between that of ISFSIs or MRS installations (*i.e.*, 4 x 10^{-4} to 5 x 10^{-4}) and nuclear power plants (*i.e.*, 1 x 10^{-4} to 1 x 10^{-5}). This position, which is presented and defended by DOE within the report, is also described within the report as being supported by the NRC (*see* DOE (2007), Section 3.1.1.1).

9. The LA does not state the basis for a 3g design requirement. Rather, Section 1.2.7.1.3.2.1 of the SAR states without explanation that:

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[1] Since publication of the 2007 DOE report, new guidance for the DBGM of nuclear power plants has been released in Regulatory Guide 1.208 (NRC, 2007). This guidance presents

> The vertical aging overpack systems must withstand a seismic event characterized by horizontal and vertical peak ground accelerations of 96.52 ft/s^2 (3g) without tipover and without exceeding canister leakage rates.

The 3g design requirement appears to be set in Section 3.3.2 of the *Transportation, Aging and Disposal Canister System Performance Specification* report (DOE, 2008b). Section 3.3.2 of DOE (2008b) repeats the 3g design requirement and refers to Attachment A of the report for details on the spectral ground accelerations that presumably influence the design requirement. Within Attachment A the only reference to the 3g design requirement is a note within the figure on page A-11 titled "Uniform Hazard Spectra – Surface Facilities Area (SFA), 2 x 10^{-6} Mean Annual Probability of Exceedance." This figure illustrates that the horizontal and vertical PGA of the surface facilities with a MAPE of 2 x 10^{-6} are between 2g and 3g. The note on the figure states that:

> These spectra form the basis for the peak ground acceleration value of 96.52 ft/s^2 (3g) cited in Sections 3.1.2 (1) (c) and 3.3.2 (1) (c).

Due to the lack of supporting information for the 3g design requirement, we interpret this figure and note as implying that the 3g design requirement is at least partially based on enveloping the 2 x 10^{-6} MAPE horizontal and vertical PGA shown in the figure.

10. Another possible justification for the 3g design requirement is provided within the *Transportation, Aging and Disposal Canister System Performance Specification Requirements Rationale* report (DOE, 2008a). In addressing the rationale for the 3g design requirement, Section 3.3.2 of DOE (2008a) states that:

> …all requirements related to the 96.52 ft/s^2 (3g) event are based on e-mail to DOE sent on May 25, 2007 with subject line "*FW: TAD spec comments*" shown in Attachment A.

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a performance based approach for determining design ground motions for nuclear power plants that results in a DBGM between the 1 x 10^{-4} and 1 x 10^{-5} MAPE ground motion.

Within Attachment A the justification for the 3g design requirement is addressed in a comment field of a revision table attached to the referenced e-mail that states:

> New requirement to account for 3g peak ground acceleration seismic event, a credible earthquake (over 50 years of operation), whose severity could lead to events not considered in Requirements 3.1.2 (1) (a) and (b).

We interpret this comment as implying that the 3g design requirement was added to the transportation, aging and disposal canister specifications because DOE believes that 3g horizontal and vertical PGA is a “credible” ground motion at the aging pads.

11. No definition of a "credible earthquake" is provided within the SAR, and no design basis or methodology used to derive the 3g design requirement is presented. However, seismic hazard curves within the LA for the surface facilities (*see* Figure 1.1-88 of the SAR) show that the 3g ground motion of the design requirement corresponds to MAPE of approximately 9×10^{-7} and 4×10^{-7} for horizontal and vertical PGA, respectively. As reviewed above, this MAPE would be extremely low with respect to the MAPE used as design bases for ISFSIs and nuclear power plants. Based on the lack of a clear, risk-informed basis for the 3g design requirement and the observation that the equivalent MAPE for the 3g ground motion is considerably more conservative than the DBGM for nuclear power plants, we contend that the 3g design requirement is excessively conservative. A more appropriate design requirement would considerably ease the storage canister design and construction specifications.

2. **<u>Conservative Hazard Curve Development</u>**

12. As described above, the basis for the 3g design requirement is not explicitly stated within the LA. However, documents referenced within the LA imply that the 3g design requirement is partially based on enveloping the horizontal and vertical PGA for a MAPE of 2×10^{-6}. In addition, hazard curves for the surface facilities show that the horizontal and vertical 3g

PGA of the design requirement corresponds to a MAPE of approximately 9×10^{-7} and 4×10^{-7}, respectively. Based on the LA and other documents, we can only assume that the 3g design requirement is at least partially derived from ground motions calculated for the Yucca Mountain surface facilities at MAPE of 2×10^{-6} and lower. Our analysis of the PSHA used to calculate these ground motions lead us to believe that the PGA calculated at MAPE of 2×10^{-6} and lower are overly conservative for the aging pads due to unnecessary, incorrect, and/or excessively conservative assumptions used in the PSHA. We believe that if more realistic and justifiable assumptions were used, PGA for the aging pads at low MAPE (*e.g.*, 1×10^{-5} and lower) would be significantly lower than the current values in the LA and would justify lowering the design requirement for the vertical aging overpacks.

13. There are five issues that we contend represent either incorrect or excessively conservative assumptions. These five issues address two fundamental components of the PSHA model: (1) equations describing the attenuation of strong ground motions, and (2) site response calculations. Each issue is discussed below.

14. The Electric Power Research Institute (EPRI) has been conducting independent evaluations of the estimated ground motions at Yucca Mountain for several years (*e.g.*, EPRI, 2005; 2006), and has noted similar issues to those discussed below. EPRI's efforts have focused on evaluating whether or not the ground motion estimates developed by the DOE for Yucca Mountain are reasonable. The basic conclusions of these reports are that DOE overestimated ground motions at Yucca Mountain and a primary cause is their treatment of uncertainty within the PSHA.

2.1 Attenuation Issue 1

15. A significant source of excessive conservatism in the ground motion equations comes from the lack of bounding estimates on the ground motions at low annual frequencies of exceedance (AFE). The essential problem is that uncertainties in ground motion equations lead to unrealistically large predicted ground motions in PSHAs at low AFEs. This effect within the Yucca Mountain ground motions is well documented in a USGS open-file report focused on the topic of the extreme ground motions predicted for Yucca Mountain (Hanks *et al.*, 2006). In Article 4 of Appendix C of the Hanks *et al*. (2006) report, Toro (2006) demonstrates this effect where he shows that the rock PGA with a 1 x 10^{-8} AFE is dominantly controlled by epsilon contributions of greater than 3, where epsilon represents the difference between ln[actual ground-motion amplitude] and ln[predicted (median) ground-motion amplitude], expressed in units of the ground-motion standard deviation σ (Toro, 2006). This and other observations made by Toro (2006) demonstrate that the extreme tails of the ground motion uncertainty distributions drive ground motions at low AFE and results in ground motions (CRWMS, 1998) that have been recognized by many experts as physically unreasonable (*e.g.*, Hanks et al., 2006).

16. One of the issues contributing to the physically unrealistic ground motions is the fact that the ground motion equations were extrapolated to AFEs beyond that for which they were originally developed. The ground motion equations used for the PSHA were developed following an expert elicitation process where individual experts developed equations given a common set of observations, data, and guidance (CRWMS, 1998). The experts were directed to develop ground motion equations designed for a minimum AFE of 1 x 10^{-4} (Hanks *et al.*, 2006). However, as discussed above, these equations were used for significantly lower AFE in developing the ground motions for surface ITS SSCs (*e.g.*, the 3g-design requirement). In

Article 3 of Appendix C of the Hanks *et al*. report (Hanks *et al.*, 2006), Abrahamson (2006), indicates that if the ground motion experts had known that their results would be used at AFEs lower than 1 x 10^{-4}, "there would likely have been additional revisions to their models" to address the applicability of the uncertainties at low AFEs and large epsilons.

17. Based on these observations, we contend that the ground motions calculated at AFE lower than 1 x 10^{-4} are excessively conservative because the ground motion experts did not evaluate appropriate limits for epsilon or the applicability of their uncertainty distributions at large epsilon for AFE levels significantly lower than 1 x 10^{-4}. Therefore, the 3g design requirement that is partially based on ground motions with AFE of 2 x 10^{-6} and lower is also excessively conservative.

<u>2.2 Attenuation Issue 2</u>

18. As described in Sections 2 and 5 of *Probabilistic Seismic Hazard Analyses for Fault Displacement and Vibratory Ground Motion at Yucca Mountain, Nevada* (CRWMS, 1998), an integral part of the expert elicitation process was a series of interactions between experts and peer reviewers addressing the preliminary attenuation relationships of each expert. These interactions were intended to ensure that the uncertainties defined by the experts were properly incorporated and to ensure the technical bases for the experts' uncertainty assessments were robust (*see* Section 2 of CRWMS (1998)). However, the peer review process was circumvented by one of the experts raising questions of the suitability of that expert's attenuation relationship. The occurrence of this circumvention is documented in Article 3 of Appendix C of the USGS open-file report on the ground motions at Yucca Mountain (Hanks *et al.*, 2006), where Abrahamson (2006) notes that:

> One expert, Anderson, made significant changes to his model in the last round of revisions. He significantly increases his epistemic uncertainty for

> the median ground motion at short distances. . . . Since these revisions came at the end of the project, they were not reviewed by the other experts.

19. One of Anderson's justifications for the last-minute changes to his model was that he was concerned with the large discrepancy between the model predictions and constraints on the maximum ground motions indicated by evidence of precariously balanced rocks (Abrahamson, 2006; Hanks *et al.*, 2006). In summary, Anderson believed that the precariously balanced rocks provided evidence that ground motions were not capable of reaching the levels predicted by the attenuation equations. If the predicted ground motions had occurred, he believed that the rocks would have fallen and no longer been precariously balanced. Therefore, Anderson increased his estimate of epistemic uncertainty. However, the technical concern addressed by Anderson's justification should only lead to increased epistemic uncertainty below the median ground motion and thus an asymmetric distribution of epistemic uncertainty. Presumably he believed that there was an increased probability of lower than originally predicted ground motions (*i.e.*, ground motions that would not topple the rocks) compared to higher than predicted ground motions (*i.e.*, ground motions that would topple the rocks) (Hanks *et al.*, 2006). Instead, of an asymmetric distribution Anderson used a symmetric distribution of epistemic uncertainty that does not reflect his original intent (CRWMS, 1998; Hanks *et al.*, 2006). In Article 4 in Appendix C of the USGS open-file report, Toro (2006) notes that one result of the changes in Anderson's model was that his model has significantly larger epistemic uncertainty than the other experts' models, and thus disproportionately influences PGA at low AFE (*i.e.*, Anderson's model has much higher PGA estimates compared to other experts (Wong, 2006; Hanks *et al.*, 2006)).

20. Based on these observations it is evident to us that Anderson's last-minute, unreviewed changes to his ground motion equation are overly conservative and have led to excessive ground motion estimates that are partially the basis of the 3g design requirement. We contend that had Anderson's changes been presented for review within the framework of the expert elicitation process, his oversight in not using an asymmetric distribution would have been corrected, and his epistemic uncertainty distribution would be less conservative and the design requirement would have a PGA lower than 3g.

2.3 Attenuation Issue 3

21. As described above, the attenuation relationship of Anderson dominates PGA at low AFE (Hanks *et al.*, 2006; Toro, 2006). Examination of the figures and results presented in Section 6 of *Probabilistic Seismic Hazard Analyses for Fault Displacement and Vibratory Ground Motion at Yucca Mountain, Nevada* (CRWMS, 1998) suggest that this large contribution of Anderson's is largely due to his large estimate of epistemic uncertainty. Attenuation issue 2 addresses several reasons why Anderson's estimates of epistemic uncertainty, and thus PGA estimates from his relationship, are excessively conservative. An additional reason for the disproportionate contribution from Anderson's relationship is that his relationship specifies that the natural-log standard deviation for mean PGA, referred to here as σ_μ, increases with increasing magnitude (*see* page F1-9 in (CRWMS, 1998)). Anderson's increase in PGA σ_μ with increasing magnitude contradicts empirical data (Youngs *et al.*, 1995), empirical ground motion results used as the basis for developing ground motion prediction relations for the Yucca Mountain PSHA (Abrahamson and Silva, 1997; Boore *et al.*, 1997; Campbell, 1997; Sadigh *et al.*, 1997; Spudich *et al.*, 1997; Spudich *et al.*, 1999), and recent findings based on additional data, which either show a reduction of σ_μ with increasing magnitude or no magnitude dependence for σ_μ

(Abrahamson *et al.*, 2008; Bommer *et al.*, 2007). Therefore, we contend that Anderson's increasing σ_{μ} with magnitude creates excessive PGA estimates and thus contribute to the excessively conservative 3g design requirement.

2.4 Attenuation Issue 4

22. Since the finalization of the attenuation equations used in the Yucca Mountain PSHA in 1998 (CRWMS, 1998), there have been considerable advances in the estimation of ground motions within the United States. Many of these advances have been incorporated into what are referred to as the Next Generation Attenuation (NGA) equations that were initially released in 2006 and finalized in 2008 (Abrahamson *et al.*, 2008). Comparison of the NGA equations to the attenuation equations that were used as the basis of the ground motion experts' evaluations for Yucca Mountain (CRWMS, 1998) leads us to believe that the attenuation equations used for Yucca Mountain are overly conservative relative to the modern state of knowledge. Relative to the equations used as the basis for the ground motion prediction equations used in the Yucca Mountain PSHA (Abrahamson and Silva, 1997; Boore *et al.*, 1997; Campbell, 1997; Sadigh *et al.*, 1997; Spudich *et al.*, 1997; Spudich *et al.*, 1999), use of the NGA equations would result in a significant reduction in estimated PGA over the entire range of annual frequencies of exceedance based on the reduction of mean PGA for normal-faulting earthquakes, reduced natural-log standard deviation for mean PGA, and decreases in epistemic uncertainties. The over-conservatism of the CRWMS (1998) ground motion prediction equations relative to NGA contributes to the high ground motions that partially form the basis for the 3g design requirement. We contend that if the NGA equations were used as the basis for the Yucca Mountain attenuation equations, over-conservatism in the estimated PGA would be reduced and a more appropriate design requirement could be utilized.

2.5 Site Response Issue

23. A critical component of estimating the aging pad ground motion, and thus the ground motion experienced by the vertical aging overpacks, is accounting for the soil amplification caused by the alluvium underlying the aging pads. We contend that the 3g design requirement is excessively conservative for the aging pads because a single, enveloping soil-response ground motion was developed for all surface facilities that is not hazard consistent and is over-conservative for the observed site conditions (*i.e.,* variable alluvium thickness) and expected soil amplification beneath the aging pads.

24. Site response calculations presented in *Supplemental Earthquake Ground Motion Input for a Geologic Repository at Yucca Mountain*, NV (Bechtel SAIC, 2008) show that PGA for the surface facilities area decreases with increasing alluvium thickness. For example, Figure 6.5.2-13 from the report (Bechtel SAIC, 2008) shows that for a MAPE of 2 x 10-6, the horizontal PGA is approximately 2.2g for a 100 ft. alluvium thickness and Figure 6.5.2-7 shows that the horizontal PGA is approximately 2.6g for a 30 ft. alluvium thickness. The final ground motions used for the surface facilities were developed from enveloping the hazard curves for alluvium thicknesses of 30, 70, 100, and 200 ft (*see* discussion in Section 1.1.5.2.6 of the LA SAR). This enveloping is not hazard consistent and is overly conservative because for each frequency the maximum ground motion from these four alluvium thickness scenarios is used as the final ground motion. For PGA, this enveloping results in the PGA ground motion being derived from a site underlain by 30 ft of alluvium. Therefore, anywhere the alluvium thickness is greater than 30 ft., the PGA estimate is unnecessarily conservative.

25. Figure 1.1-130 of the LA SAR shows that the alluvium thickness beneath the surface facilities (including the aging pads) varies between 50 ft and 180 ft, with the vast

majority of the aging pad area underlain by alluvium over 100 ft thick. We contend that the PGA estimate derived within the LA is excessively conservative for the aging pads because the PGA is based on site amplification estimates developed for a site underlain by 30 ft of alluvium. Therefore, the 3g design requirement is overly conservative.

Michael G. Gray

Christopher W. Fuller

Daniel R.H. O'Connell

Sworn and subscribed to before me this 10 day of December 2008.

THEA R. CARRILLO
Commission # 1611825
Notary Public - California
Contra Costa County
My Comm. Expires Oct 8, 2009

Notary Public

My Commission expires: 10-8-09

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Michael G. Gray

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Christopher W. Fuller

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Daniel R.H. O'Connell

Sworn and subscribed to before me this 10th day of Dec. 2008.

ERIN SEXTON
NOTARY PUBLIC
STATE OF COLORADO
My Commission Expires 8/06/2012

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Notary Public

My Commission expires: 8/6/2012

References:

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ATTACHMENT 10

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of:	)	
	)	
U.S. Department of Energy	)	Docket No. 63-001
(High Level Waste Repository	)	
	)	
	)	

AFFIDAVIT OF BRIAN GUTHERMAN IN SUPPORT OF PROPOSED CONTENTION NEI-SAFETY-03

Brian Gutherman, being duly sworn, states as follows:

1. I, Brian Gutherman, am a Vice President of Advanced Concepts, Inc. (ACI) of Scottsdale, Arizona. My Bachelor's Degree is in Mechanical Engineering. I have extensive experience in the field of nuclear power plant design, operation and licensing. I earned a senior reactor operator's certification at the Crystal River Unit 3 plant. My professional work has focused on mechanical design engineering, system engineering, and licensing in support of nuclear power plants. My full Statement of Professional Qualifications is Attachment 17 to the Nuclear Energy Institute (NEI) Petition to Intervene.

2. I have been involved professionally in nuclear power plant design, licensing, operation, and regulatory policy for over 26 years, the last ten years of which have focused on commercial spent nuclear fuel (SNF) storage and transportation. I serve as President of ACI Nuclear Energy Solutions, a New Jersey-based division of ACI with responsibility for the company's spent fuel management consulting business. I have been working in this capacity for ACI for two years.

3. I currently assist nuclear power plant owners in implementing dry spent fuel storage at onsite Independent Spent Fuel Storage Installations (ISFSIs) and by performing third-

party assessments of ISFSI operations. I also provide spent fuel management consulting services to NEI.

4. I have been engaged by NEI to evaluate certain aspects of the License Application (LA) and Safety Analysis Report (SAR) related to seismic design submitted to the Nuclear Regulatory Commission (NRC) by the Department of Energy (DOE) for the proposed high level nuclear waste repository at Yucca Mountain, Nevada. In particular, Section 1.2.7.1.3.2.1 of the LA Safety Analysis Report (SAR) states that the vertical aging overpack system of the aging facility "must withstand a seismic event characterized by horizontal and vertical peak ground accelerations of 96.52 ft/s^2 (3g) without tipover and without exceeding canister leakage rates." I contend that the 3g design requirement could significantly increase the costs of the aging overpack system. In addition, depending on the design ultimately adopted for that system, additional time may be required for installation of the system (*e.g.*, installing structural restraints or other apparatus), thereby increasing occupational doses to workers.

5. The vertical aging cask systems proposed for the Yucca Mountain repository are similar in design to the commercial vertical ventilated casks systems used at power plant ISFSIs. The Yucca Mountain aging casks are cylindrical overpacks containing a transportation, aging and disposal (TAD) canister oriented in a vertical configuration (TAD Specification, DOE Document ID WMO-TADCS-000001, Revision 1, Section 3.3.1, p. 23). TAD canisters are approximately the same height and diameter as commercial dual purpose canisters (TAD Specification, DOE Document ID WMO-TADCS-000001, Revision 1, Section 3.1.1, p. 9).

6. Free-standing commercial vertical cask storage systems are designed not to tip over or experience an unacceptable amount of sliding under the forces resulting from a seismic event. The cask designers establish the site seismic acceleration criteria required to be met by the cask user in order to deploy the cask in an unanchored or unrestrained mode (*i.e.*, free-

standing). For example, the seismic criteria for the NAC International UMS System and the Holtec International HI-STORM 100 System are as follows:

a. NAC UMS: 0.26g horizontal and 0.26g vertical at the top surface of the ISFSI pad or at the center-of-gravity of the concrete cask (NAC-UMS CoC, Amendment 4, Appendix B, Section B3.4.1.3(a)).

b. Holtec HI-STORM 100: The site seismic criteria must satisfy the following inequality (HI-STORM CoC, Amendment 5, Appendix B, Section 3.4.3.a):

i. $G_H + \mu G_V \leq \mu$, where G_H is the horizontal zero-period acceleration (ZPA), G_V is the vertical ZPA at the surface of the ISFSI pad, and μ is the Coulomb friction coefficient between the cask/ISFSI pad interface or the ratio r/h, where 'r' is the radius of the cask and 'h' is the height of the cask center-of-gravity above the ISFSI pad surface. This inequality must be met for both definitions of μ.

7. The HI-STORM 100 System also includes an anchored variant of its overpack design for so-called "high-seismic" sites. "High-seismic" sites are those that have design basis seismic acceleration values that may overturn or cause excessive sliding of free-standing casks. The anchored overpack design is based on the following design basis seismic accelerations (HI-STORM CoC, Amendment 5, Appendix B, Section 3.4.3.c):

a. $G_H \leq 2.12$ and $G_V \leq 1.5$

8. The aging casks at the Yucca Mountain repository are specified to be free-standing and must remain upright during and after the 3g earthquake (TAD Specification, DOE Document ID WMO-TADCS-000001, Revision 1, Section 3.3.2.(1).c, p. 24). This requirement means that the aging casks cannot be anchored to the pad and the aging casks will likely be

designed differently from current dry storage systems, possibly with some structural element or apparatus to prevent overturning. Installation of such an element or apparatus, adjacent to each previously loaded aging cask, will cause the workers involved to receive a higher radiation dose than if the cask could be deployed in the free-standing mode.

9. An estimate of the additional dose is 80 person-mrem for each apparatus installed. This dose was estimated assuming the following:

a. A 5 mrem/hr radiation field in the vicinity of the cask for which the apparatus is being installed, plus the radiation from adjacent casks. This dose rate may actually be higher or lower depending on the source term of the contents inside each aging cask.

b. A four-person installation crew.

c. The installation takes four hours to complete.

10. Section 1.2.7.1 of the Yucca Mountain LA SAR states that the aging facility will accommodate up to 2,500 aging casks. At 80 person-mrem per installation, the total estimated additional occupational dose would be 200 person-rem.

Brian Gutherman

Sworn and subscribed to before me this 12th day of December 2008.

ANA M. LANGENBACH
NOTARY PUBLIC
STATE OF NEW JERSEY
MY COMMISSION EXPIRES JULY 24, 2012

Notary Public

My Commission expires: 7/24/12

DC:569557.1

NEI-SAFETY-03

ATTACHMENT 11

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of:	)	
	)	
U.S. Department of Energy	)	Docket No. 63-001
High Level Waste Repository	)	
	)	
	)	

AFFIDAVIT OF MICHAEL J. APTED AND MEGHAN M. MORRISSEY IN SUPPORT OF PROPOSED CONTENTION NEI-SAFETY-04

Michael J. Apted and Meghan M. Morrissey, being duly sworn, state as follows:

1. I, Michael J. Apted, Ph.D., am the President of Monitor Scientific LLC, which specializes in environmental systems assessment. I have a Bachelor of Science degree in Chemistry and my advanced degree is in Geochemistry. I have over twenty five years of experience in research and development related to nuclear waste disposal, including eighteen years as a consultant to national and international nuclear waste agencies, including the National Academy of Sciences, the International Atomic Energy Agency, and the Nuclear Energy Agency. My full Statement of Professional Qualifications is Attachment 22 to the Nuclear Energy Institute (NEI) Petition to Intervene.

2. I, Meghan M. Morrissey, Ph.D., am a Research Professor at the Colorado School of Mines, with research focusing on volcanic hazards. I have a Bachelor of Science degree in Geological Engineering and my advanced degrees are in Geology. I have over fourteen years of experience in research and development related to natural hazards associated with active volcanoes and landslides, including consulting for the U.S. Geological Survey to develop

numerical hazard models. My full Statement of Professional Qualifications is Attachment 23 to the NEI Petition to Intervene.

3. We have conducted a variety of research studies for the Electric Power Research Institute (EPRI) related to repository performance issues that include igneous event issues (EPRI, 2004, Potential Igneous Processes Relevant to the Yucca Mountain Repository: Extrusive-Release Scenario, Technical Report 1008169, Electric Power Research Institute, Palo Alto, CA; EPRI, 2005, Program on Technology Innovation: Potential Igneous Processes Relevant to the Yucca Mountain Repository: Intrusive-Release Scenario, Technical Report 1011165, Electric Power Research Institute, Palo Alto, CA). We have been engaged by the NEI to evaluate aspects of the License Application (LA) and Safety Analysis Report (SAR) submitted to the Nuclear Regulatory Commission (NRC) by the Department of Energy (DOE) for the proposed high level nuclear waste repository at Yucca Mountain, Nevada. Our focus in this affidavit relates to consequences of an igneous event impacting the site as reflected in the DOE Total System Performance Assessment (TSPA-LA). We make this affidavit jointly, based on our review of the LA, LA SAR, TSPA-LA, and related reference materials, in support of proposed contention NEI-SAFETY-04. Unless otherwise noted, we both jointly sponsor all statements in this affidavit.

Overview

4. Section 2.3.11 (p. 2.3-1) of the LA SAR states that “future igneous activity at the site (repository) is included in the features, events and processes (FEPs) that are incorporated in the TSPA-LA for the repository because [of] the mean annual probability of intersection of the repository by an igneous event. . . .” The TSPA-LA model and repository assessment analysis described in LA SAR (Section 2.4.1.1) “follow the requirements in proposed 10 CFR 63.342(c)

by projecting the continued effects of the 10,000 year screened-in FEPS through the period of geologic stability (up to 1,000,000 years after permanent closure), and including the effects of seismic events, igneous events, climate change and general corrosion beyond 10,000 years." (p. 2.4-10). As stated in Section 2.4.1.2 (p. 2.4-11) the TSPA-LA calculation in LA SAR "calculates the total annual dose as the sum of the annual doses attributed to the nominal scenario class, the early failure class and the two disruptive event scenario classes (igneous scenario class and seismic scenario class)." DOE notes in Section 2.4.2.2.1.1.2 (p. 2.4-57) of the LA SAR, that the mean annual doses calculated for the igneous intrusive modeling case is one of the two dominant contributors (~40%) to the total dose; "all other modeling cases for both the 10,000 year and post-10,000 year time periods comprise on the order of 1% or less of the total mean annual dose."

5. As stated in the LA SAR (Section 2.3.11.3.2.4, p. 2.3.11-32), "for TSPA-LA, it is assumed that (1) following intersection of the repository, all drifts are rapidly filled with magma; (2) all waste packages in drifts are engulfed in magma; and (3) the waste packages contacted by magma are damaged and fail, providing no protection for the waste from groundwater (SNL 2007b, Section 5.1)". DOE also states (Section 2.3.11.3.2.3**,** p. 2.3.11-32**)** that "the approach taken (in TSPA-LA calculation) is to model the dynamic conditions as rising magma first intersects and then flows into a drift for both the effusive and pyroclastic end member cases. For the purposes of TSPA-LA, the details of these processes are simplified such that all waste packages that are contacted by magma are assumed to fail in terms of their ability to contain spent fuel (SNL 2007b, Section 5.1)."

6. We contend that DOE's (TSPA-LA) estimate of the contribution to mean annual dose related to the igneous scenario class is excessively conservative as a result of its simplified,

overly conservative assumptions in the igneous intrusive modeling case. These include DOE's assumptions regarding (1) magma behavior (DOE's assumptions (1) and (2) mentioned in the above paragraph) and (2) waste package failure (assumption (3) mentioned in the above paragraph). These assumptions are unreasonably pessimistic and inconsistent with DOE's related FEP assessments. Each of these assumptions is discussed below. We further contend that if a "reasonably expected" igneous scenario was considered by DOE, the related consequences would show no significant release of radionuclide exposure, thereby reducing the total TSPA-LA dose estimate (EPRI, 2004, Chapter 11 Summary, pp. 11-1 to 11-3; EPRI, 2005, Chapter 9 Summary, pp. 9-1 to 9-3).

Issue 1: Magma Behavior

7. DOE states in Section 2.4.2.3.2.1.12.2 (p. 2.4-193), that the "igneous intrusion modeling case represents a potential basaltic dike intersecting the repository without surface eruption within the repository boundary … and the flow characteristics of the intruding magma are assumed to be such that it fills every drift within the repository." Furthermore, DOE states that their model (Section 2.3.11.3.2.7, p.2.3.11-34) "assumes that all drifts in the repository are filled with magma if any drift (including access and exhaust drifts) in the repository is intersected (SNL 2007a, Section 5.1). Because all drifts are assumed to be filled with magma following an igneous intrusion, all waste packages [11,692 waste packages] in the repository are contacted by magma." As discussed further below, we conclude that these assumptions by DOE are excessively pessimistic. Alternate assumptions in line with reasonable expectation would be that not all drifts will be intersected by a potential dike and that the magma can travel only some partial distance down an intersected drift before cooling and solidifying. Therefore, magma from a postulated igneous event will not fill the entire repository and engulf all waste packages.

Issue 2: Waste Package Failure and Radionuclide Release

8. As stated in Section 2.4.1.2.3 (p. 2.4-17) in the LA SAR, "in the (DOE) igneous intrusion modeling case, magma from a dike(s) that intersects one or more repository drifts is assumed to engulf all drip shields and waste packages in the repository, rendering them incapable of protecting their contents." DOE also states (page 2.3.11-10) that "lacking a demonstrated natural or engineered means to limit magma flow from intersected to non-intersected drifts the intrusion case assumes that, if intersection occurs, all waste packages in all drifts will be contacted by magma and damaged to the extent that they provide no protection for the waste." In the TSPA-LA calculation, DOE assumes that radionuclides dissolved in water moving through the basalt will be transported by the groundwater downward through the invert and the unsaturated zone to the water table. Once contacted by magma, the waste packages are assumed to fail and provide no protection for waste from contact by groundwater (SNL 2007a, Section 5.1). DOE assumes that the rate of cooling of magma in the drift depends mainly on the rate of the thermal diffusivity of the welded tuff and the basalt, which are assumed to be the same (SNL 2007a, Section 5.4). The presence of waste packages and engineered barriers are considered in DOE's analysis of magma cooling and are assumed to have similar thermo-mechanical properties as the wall rock and basalt (Table 4-1, SNL 2007b). The thermo-mechanical properties of a waste package such as conductivity are actually roughly one order of magnitude greater than basalt or welded tuff (BSC, 2005). We believe that a more reasonable model would consider heat transfer mechanisms expected in the drifts (such as the thermal diffusivity of the waste packages and barriers). We also believe a more reasonable model would consider realistic constraints on magma-waste package interactions (EPRI, 2004; Chapter 4 and 5; 2005, Chapters 3 and 4, 2007).

EPRI's Igneous Event Analysis

9. EPRI (2005; Chapters 6 to 8, 2007) carried out an independent assessment of the consequences of an intrusive event. EPRI concluded that "[t]here is reasonable expectation that the magma will only affect some waste packages in a drift intersected by a rising dike, with the remaining waste packages in the impacted drifts functioning the same as they would in drifts not intersected by a dike. In this situation, the peak conditional dose from the affected part of the repository is smaller than that produced from the unaffected part of the repository, due to the small percentage of the total repository waste packages impacted [see EPRI, 2005, Table 3-5, pp. 3-26 to 3-27]. If the probability of a magma intrusion is also factored in, the contribution to overall probability-weighted peak dose becomes minuscule [see EPRI, 2005, page 8-5]. Even when a series of conservative, 'bounding' assumptions are made (*e.g.*, full penetration of the magma into the drifts, and 100% of the drifts affected), the probability-weighted estimated bounding dose rates only rise to be on par with the peak dose rates from the nominal case. EPRI therefore concludes that there is reasonable expectation that magma intrusion is inconsequential with respect to peak dose" (EPRI, 2005, page vi).

10. In contrast to the DOE assumption, EPRI estimates the number of drifts that would be intersected by a dike would range between 5 and 41, assuming that a dike intersects the repository with an azimuth parallel to the N25-30E direction of maximum compressive horizontal stress (Stock *et al.*, 1985) and for a dike length between 0.4 km and 3.5 km as described in EPRI's independent PVHA analysis (EPRI, 2007). The maximum number of intersected drifts is estimated by dividing the dike length by the summation of the drift diameter (5 m) and the drift spacing (81 m). EPRI's estimated range of 5 to 41 intersected drifts compares well to DOE's own pre-LA analysis of dike intersection with emplacement drifts (BSC, 2003),

which estimated 14 emplacement drifts as the median value for emplacement drifts that might be intersected by a future igneous dike at Yucca Mountain (see EPRI, 2005, pp. 8-1 to 8-5).

11. EPRI also concludes that magma will not impact all waste packages in intersected drifts. EPRI's conclusions in this regard are based on a conceptual model specifically developed for an expected igneous event at the Yucca Mountain (YM) region (EPRI, 2004; 2005; 2007). EPRI's model is based on available geological, geochemical, and geophysical data from DOE and other agencies and academic institutions (*i.e.*, Crowe and Carr, 1980; Perry *et al.*, 1998; Nicholis and Rutherford, 2004; Valentine *et al.*, 2005; 2006; 2007; Valentine and Perry, 2006). A key difference between EPRI's conceptual model and that of DOE is the expected behavior of magma (lava) inside a drift.

12. DOE (LA SAR, Sections 2.3.11.2.1.2 and 2.3.11.3.1; p. 2.3.11-19 and 2.3.11-27) assumes that alkali basalt will enter a drift at a temperature of 1046-1169^{o}C with a viscosity of 10-40 Pa-s based on an experimental study conducted by Knutson and Green (1975) on Hawaiite basalts from Southern Wales that contain large phenocrysts of olivine, pyroxene, and plagioclase. Basalts from Southern Wales are very different in terms of petrology and chemistry than basalts from the YM region. In the 2005 Intrusive Pathway Release Scenario, EPRI (2005) discusses the recent experimental study on Crater Flat basalts by Nicholis and Rutherford (2004), who demonstrate that the liquidus temperature for Crater Flat basalts is 100-200^{o}C lower than that previously assumed. EPRI adopts a maximum temperature of 950-1010^{o}C in all its analyses of basalt behavior. "The analyses … support the conclusion that relatively low-temperature (~1010˚C), high-viscosity basaltic magmas, as opposed to the ~ 1150˚C magmas postulated by the DOE, are the most representative characteristics of future igneous events in the YM region. Lower temperature implies lower and less prolonged thermal-perturbation of the host rock and

contacted waste packages, and magma of much higher viscosity. The high viscosity supports the contention that such magma will only partially flow into emplacement drifts intersected by the magmatic dike and not fill the entire repository and thereby only impacting a limited number of waste packages" (EPRI, 2005, page viii).

13. In line with EPRI's views, the Advisory Committee on Nuclear Waste (ACNW 2007) state in their final report on "Igneous Activity at Yucca Mountain: Technical Basis for Decision Making," that "the major factors in determining risk from the intrusive scenario, in addition to the probability of the event, are the number of waste packages affected by the intruding molten rock (magma) determined by the viscosity of the magma …" (p. xi). The ACNW, an independent scientific advisory panel for the NRC, goes on to say that the flow rate of magma inside a drift "strongly depends on the magma viscosity and the rate of solidification as it contacts the relatively cold drip shield, waste packages and drift walls" (p. 31). The ACNW also cites recent work by Marsh and Coleman (2006) that demonstrates that magma viscosities expected for a future igneous event at YM "would be several orders of magnitude greater than previously assumed [by DOE], which would reduce the rate of magma entry into drifts. The potential critical effects of quenching and solidification on waste packages and drift walls have not fully been evaluated by DOE or NRC" (p.31). The ACNW provides a detailed discussion of their viscosity analysis in Section 6.2.1.2 (p. 95) of their report (ACNW, 2007) and conclude that magma (lava) at the YM region will be water-bearing basalts that will be relatively immobile.

14. We recently (Morrissey *et al.*, 2008) performed calculations on the expected cooling history of lava inside a drift using an approach for assessing the thermal budget inside a lava tube (Keszthelyi, 1995). The lava tube approach evaluates and quantifies various modes of heat transfer that may act on a lava flow. Four modes of heat transfer are assumed to occur

inside the drift: degassing, conduction, viscous dissipation and latent heat crystallization. For simplicity, it is assumed that the drift is circular, and lava enters at a steady state and is degassed. For the purpose of evaluating the flow behavior of lava inside a drift, the thermal budget equation (Keszthelyi, 1995) is solved for cooling as a function of distance (units of ^{o}C/km) from the point where lava enters the drift. The estimated effusion rates for possible basaltic lavas in the YM region are 0.001-0.1 m^3/s based on maximum lava flow lengths of 0.4-1.8 m observed for the < 4.8 million year old basalt flows in the Yucca Mountain region (Valentine and Perry, 2006). Lower effusion rates are estimated inside a drift because as lava enters a drift it will decompress from 7-10 MPa to 0.1 MPa. Rapid decompression of magma with < 1 wt.% H_2O results in 20^{o}C undercooling and 10-20% crystallization. This raises the viscosity 1-2 orders of magnitude and decreases the flow velocity in the drift where lava entered the drift. Under such conditions, effusion rates of 0.001-0.00001 m^3/s are expected inside a drift that corresponds to a cooling with distance range of 90-1200^{o}C/km. These cooling with distance values indicate that lava upon entering a drift will approach its solidus temperature (950^{o}C) within 10 meters down the drift when the temperature and crystallinity dependence on viscosity is considered. Results from these calculations demonstrate that DOE's assumption that an igneous intrusion intersecting the repository will flood the entire repository is excessively conservative. EPRI's results demonstrate that if an igneous intrusion intersects a drift, magma will only flow a very limited distance (<10 m) down the drift before its freezes due to viscosity limitations.

15. Hence, in EPRI's analysis, both the number of drifts intersected and the distance that magma travels down the drifts dictate that only a limited number of waste packages would be affected by a potential igneous intrusion event. These results are in direct contrast and opposition to DOE's current LA analysis, wherein both factors are rendered irrelevant by the

excessively conservative assumption that if only one drift is intersected by a future magmatic dike, then the entire repository would fill with magma and every waste package in the repository would be affected by this magma engulfment. The EPRI results support NEI's contention that the igneous-intrusion consequences assumed in DOE's LA are excessively high. We conclude that a potential dike would intersect only a few of the emplacement drifts, and in those few intersected drifts magma will only flow a very limited distance inside a drift and contact only a very small number of waste packages.

Waste Package-Magma Interactions

16. EPRI further concludes in its intrusive igneous scenario that magma in direct contact with a waste package will rapidly cool, forming a solid, crust barrier around the waste package, thus providing a protective barrier (EPRI, 2005). The EPRI (2005) report evaluated magma-waste package interactions potentially mitigating radionuclide release by considering three separate types or 'zones' of interaction. These results are summarized in Table 6 of EPRI (2005).

17. In EPRI's (2005) study, a 'red zone' was identified to include waste packages in direct contact with magma. Because of EPRI's consideration of a higher magma viscosity and associated heat-losses to engineered barriers and surrounding tuff than those by DOE, the number of waste packages in the 'red zone' was limited to 6 waste packages per intersected drift. While waste packages in direct contact with magma were considered to result in failure of the waste package due to internal pressurization (EPRI, 2005, Table 3-5), EPRI evaluated the type of failure processes that could act on the waste package. EPRI found that waste packages did not fail catastrophically but failed on a very small area of the waste package, thus limiting potential access of magma or water into the failed package. EPRI also demonstrated that encasing

solidified basalt would create a protective barrier that would provide additional transport constraints on radionuclides that might be released from failed waste packages in the 'red zone.'

18. In EPRI's evaluation (2005) of waste package-magma interaction, the "blue zone" considered waste packages that were assumed to be close enough to the front of the magma plug to experience significant thermal impacts, notably earlier than expected containment failure by mechanical creep (EPRI, 2005, Table 3-5). Analysis of temperature-time conditions, however, indicated that the magnitude and duration of elevated temperature of waste packages in front of the magma intrusion would be insufficient to lead to internal pressurization and loss of containment by the Alloy-22 outer barrier of the waste package. The cladding of waste packages in the 'blue zone' would exceed the 350˚C temperature limit identified in the LA, but it is noted that the performance assessments in the LA do not assume containment credit for cladding in any case.

19. EPRI (2005) also evaluated waste packages inside a drift that may be in contact with reactive volatiles from the degassing magma refers to as the "green zone." Analyses indicated that waste packages within 80-100 m (15-18 waste packages) in front of a magma intrusion may remain relatively cooler than the neighboring drift walls within the first 500 years following the igneous event/ magma intrusion, leading to sustained contact of Alloy-22 with these reactive gases. However, conditions suitable for enhanced corrosion of waste packages in the 'green zone' are too brief (less than a few years) for this potential failure mechanism to be of concern (EPRI, 2005, Table 3-5). At distances greater than 100 m, the drift walls would be cooler than the waste packages, promoting the dissipation, dilution and chemical neutralization of reactive volatile species within the tuff-pore water system.

20. An additional factor that would tend to mitigate the consequences of an igneous intrusive event is the mechanical and chemical durability of spent fuel pellets and cladding (EPRI, 2004, Chapter 6 and Appendix C). According to ACNW (2007, p. 141), "[t]he size of the lithic fragments suggests that spent nuclear fuel pellets and fragments could be expelled in similar fashion during the cone-building phase of an eruption, intact and with protective quench rinds. The result is that entrained HLW would be likely to remain in relatively large fragments that would be deposited in or near a tephra cone, rather than as far-strewn, fine-grained ash." This result also suggests that the spent fuel would remain largely intact for the extrusive case as well.

21. EPRI (2005) combines these waste package-magma interactions into a series of dose calculations to evaluate the igneous-intrusive scenario. Even for extremely pessimistic assumptions about the cumulative probability of an igneous event, the EPRI (2005) study calculated a mean dose peak below 0.1 millirem/y when considering the various mitigating effects of waste package-magma interactions in 'red', 'green' and 'blue' zones. This calculated dose rate is more than two orders of magnitude less than the draft EPA regulatory limit.

<u>Conclusions from EPRI'S Consequence Studies</u>

22. Based on the EPRI work (2004; 2005; 2007; Morrisey et al., 2008), as well as the work by the ACNW (2007), we conclude:

- The key DOE assumptions in the LA SAR (Section 2.3.11.3.2.4, p. 2.3.11-32) are unnecessarily simplified and extremely conservative, leading to significant underestimation of the safety margin for the reference LA repository concept based on higher than "reasonably expected" doses calculated and reported in the TSPA-LA. These key assumptions that we challenge include: (1) all drifts are rapidly filled with magma;

(2) all waste packages in drifts are engulfed in magma; (3) the waste packages contacted by magma are damaged and completely fail, providing no protection for subsequent contact of waste by magma and/or groundwater; (4) no mitigation of later radionucldie release through encompassing solidified basalt; and (5) complete mechanical breakdown of spent fuel material leading to ready availability of radionuclides for transport away from the repository.

- The treatment of the igneous intrusion scenario in the LA SAR excludes many factors that would mitigate the consequences of the event, including lower eruption temperature, higher magma viscosity, rapid quenching and solidification of magma, limited failure of waste packages, mechanical and chemical durability of spent fuel, and potentially mitigating benefits from encasement of waste packages by magma.

Michael J. Apted

Meghan M. Morrissey

Sworn and subscribed to before me this 16 day of DEC 2008.

Notary Public

My Commission expires: 10.19.09

References:

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ATTACHMENT 12

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of:	)	
	)	
U.S. Department of Energy	)	Docket No. 63-001
(High Level Waste Repository)	)	
	)	
	)	

AFFIDAVIT OF EVERETT L. REDMOND II,
IN SUPPORT OF PROPOSED CONTENTION NEI-SAFETY-05

Everett L. Redmond II, being duly sworn, states as follows:

1. I, Everett L. Redmond II, Ph.D., M.S., am a Senior Project Manager employed by the Nuclear Energy Institute, NEI, of Washington, D.C. My Bachelor of Science degree and my advanced degrees are in Nuclear Engineering. I have extensive experience in the areas of shielding and criticality calculations. Prior to joining NEI in 2006, I was employed for more than ten years with Holtec International of Marlton, New Jersey. Holtec International is a leading supplier of used fuel storage technology for commercial nuclear power facilities. While at Holtec International, my professional work focused on performing and reviewing criticality and shielding calculations for spent fuel pool storage racks and dry cask storage systems. Since joining NEI, my professional work has focused on managing generic commercial nuclear power industry regulatory issues including criticality burnup credit. My full Statement of Professional Qualifications is Attachment 24 to the Nuclear Energy Institute (NEI) Petition to Intervene.

2. I am employed by the Nuclear Energy Institute (NEI) and have been asked to evaluate certain aspects related to postclosure criticality of the License Application (LA) and Safety Analysis Report (SAR) submitted to the Nuclear Regulatory Commission (NRC) by the

Department of Energy (DOE) for the proposed high level nuclear waste repository at Yucca Mountain, Nevada. I have prepared this affidavit, based on my review of the LA, SAR, and related reference materials, in support of proposed contention NEI–SAFETY-05.

Overview

3. Section 2.2.1.4.1.1 of the LA Safety Analysis Report (SAR) describes the postclosure criticality analysis with respect to methodology in detail. It is common practice in criticality analyses to use conservative values to bound the wide range of variability in important parameters. The analysis described in the LA is generally consistent with this approach as illustrated by the use of conservative parameters (e.g. fuel temperature, moderator temperature) for the depletion analysis (Section 2.2.1.4.1.1.2.2 of the LA Safety Analysis Report). However, NEI submits that certain aspects of the postclosure criticality analysis, as described in detail below, are unnecessarily and excessively conservative.

4. The postclosure criticality analysis described in Section 2.2.1.4.1.1 of the LA Safety Analysis Report (SAR) determines an allowable burnup versus enrichment criterion for fuel assemblies which is depicted in Figures 2.2-7 and 2.2-8 of the SAR. As described in Section 2.2.1.4.1.1.3, disposal control rod assemblies will be required to be inserted into those fuel assemblies that fall within the “Not Acceptable” area on these figures. Inserting these disposal control rod assemblies into fuel assemblies at the nuclear power plants exposes workers to increased radiation exposure, creates unnecessary expenditures from the Nuclear Waste Fund, and may result in licensing delays for approving a Transportation, Aging and Disposal (TAD) cannister design, that could be obviated by reducing the excessive conservatism in the postclosure criticality analysis while still maintaining a reasonable level of conservatism. More reasonable assumptions in this regard are discussed below.

Design Basis Configuration Excessive Conservatisms

5. Section 2.2.1.4.1.1.2.1 of the LA SAR states: "Irrespective of the relevant probabilities, for all waste forms the design basis configuration that is used to assess the potential for a criticality event assumes full flooding with water and neutron absorber material that is degraded, beyond the maximum credible extent." While assuming full flooding with water is conservative, this bounding calculation is not required by the regulation (10 CFR 63.114). Therefore, NEI submits that the LA SAR should have analyzed more realistic, yet conservative, scenarios of water intrusion into the commercial spent nuclear fuel waste packages. Analyzing configurations that are not fully flooded will result in calculated k-effectives that are considerably lower than those calculated with a fully flooded configuration and will lower the allowable burnup versus enrichment curve. Lowering the curve will increase the number of assemblies that do not require disposal control rod assemblies. There is precedent, within NRC guidance, for not assuming a fully flooded configuration. Interim Staff Guidance 19 in the NRC Division of Spent Fuel Storage and Transportation, permits the licensee to analyze the most credible configuration for accident scenarios rather than a fully flooded configuration. Therefore, a similar approach should have been taken in the LA since the regulations do not require a fully flooded configuration.

6. Section 2.2.1.4.1.1.2.2 of the LA states that a neutron absorber thickness used in the criticality analysis of the TAD canister is less than the predicted thickness based on 10,000 years of general corrosion. The LA also states that the value used is 6 mm and that the predicted thickness is greater than or equal to 9 mm. This 33% reduction in absorber thickness is arbitrary and results in an excessively conservative criticality analysis. There is no regulatory basis for assuming such conservatism, in this case an arbitrary 33% reduction, in the absorber thickness

compared to the predicted value. Criticality analyses performed for NRC licensing efforts typically assume either a nominal absorber thickness or a minimum absorber thickness without any additional penalty. Analyses performed for spent fuel pools typically assume nominal neutron absorber thickness and account for manufacturing tolerances while analyses of dry cask storage systems typically assume minimum neutron absorber thicknesses. In either case, an additional arbitrary reduction in thickness is not applied. That approach is unjustified, at odds with DOE's own prediction, and is unnecessarily conservative.

7. Section 2.2.1.4.1.1.2.2 of the LA states that the criticality analysis is only taking credit for 75% of the neutron absorber content in the neutron absorber material consistent with NUREG-1536, NUREG-1617, and NUREG-1567 which are the Standard Review Plans (SRP) for dry cask storage and transportation systems and facilities. It should be noted that these NUREGs also permit the licensee to take credit for a higher percentage if additional fabrication testing is performed. Various licensees have received approval of designs while taking credit for 90% of the neutron absorber content with the imposition of additional manufacturing requirements. Therefore the LA should allow for the use of realistic credit for the neutron absorber content rather than defaulting to the 75% credit mentioned in the NUREGs.

8. Section 2.2.1.4.1.1.2.2 of the LA states that the isotopic compositions for use in the criticality calculation will be calculated for a cooling time of 5 years. The LA states that this is “not actually possible given the preclosure time frame” of 100 years. Therefore, the use of 5 years cooling time is arbitrary and unreasonably short. A more appropriate cooling time consistent with the preclosure time frame and the inventory of fuel that will be emplaced should have been used for the postclosure criticality analysis.

9. Section 2.2.1.4.1.1.2.4.1 describes the development and use of a calculational bias based on measured radiochemical assay data. This calculational bias is used to account for potential uncertainty in the calculation of the isotopic compositions of burned fuel assemblies. This approach is loosely based on the NRC guidance for criticality analyses for spent fuel transportation outlined in the Division of Spent Fuel Storage and Transportation Interim Staff Guidance-8 Revision 2. However, criticality calculations that are performed for wet storage pools at nuclear reactor facilities do not use a bias based on radiochemical assay data (Kopp memorandum). Rather, these calculations account for the uncertainty in the depletion calculations by utilizing a penalty which is equivalent to 5% of the reactivity difference between a calculation of the configuration with fresh fuel and burned fuel. This approach yields a penalty which is appropriately adjusted increasing with increasing burnup and decreasing with decreasing burnup, and that is considerably smaller than the bias calculated from the radiochemical assay data (-0.0249 Δk). Therefore, the LA and NRC guidance in ISG-8 Revision 2 are overly conservative in this regard and it would be more reasonable to allow for the approach that has been approved by NRC in wet storage criticality analyses rather than an approach based on radiochemical assay data.

10. Revising the criticality analysis as discussed above would still maintain a high level of conservatism while decreasing the operational burden and dose by eliminating the need for disposal control rod assemblies.

Everett L Redmond II

Sworn and subscribed to before me this 17 day of December 2008.

Notary Public

My Commission expires: My Commission Expires August 14, 2012

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ATTACHMENT 13

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of	)	
	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
(High-Level Waste Repository)	)	
	)	

AFFIDAVIT OF DR. MATTHEW W. KOZAK, DR. MICHAEL J. APTED, AND DR. FRASER KING IN SUPPORT OF PROPOSED CONTENTION NEI-SAFETY-06

Dr. Matthew W. Kozak ("MK"), Dr. Michael J. Apted ("MA"), and Dr. Fraser King ("FK"), being duly sworn, state as follows:

1. Introduction

1.1 Dr. Matthew W. Kozak

1. (MK) I am a Principal Consultant of Monitor Scientific LLC, Denver, Colorado. My statement of professional qualifications is included with the NEI Petition at Attachment 16.

2. (MK) Monitor Scientific LLC is under contract to the Nuclear Energy Institute ("NEI") to assist NEI in developing contentions, including NEI-SAFETY-06, "Drip Shields are Not Necessary", for its intervention petition for the construction authorization licensing proceeding for the proposed high-level waste repository at Yucca Mountain, NV pending before the Nuclear Regulatory Commission ("NRC" or "Commission").

3. (MK) I have a Bachelor's degree in chemical engineering from Cleveland State University, and a Ph.D. in chemical engineering from the University of Washington. I have been involved professionally in radioactive waste management and disposal assessment, technology,

and regulatory policy for more than 19 years, including more than 10 years of active work on safety of the proposed repository at Yucca Mountain.

4. (MK) I participate in a project for the Electric Power Research Institute's ("EPRI") oversight of post-closure safety for the proposed repository at Yucca Mountain, and have been associated with EPRI's program for more than 10 years.

5. (MK) I am co-author of EPRI's independent total system performance assessment reports on Yucca Mountain, including EPRI's post-closure safety assessment code IMARC. I have also co-authored several EPRI studies on the performance of the Yucca Mountain repository, and am familiar with the EPRI report entitled, "Occupational Risk Consequences of the Department of Energy's Approach to Repository Design, Performance Assessment and Operation in the Yucca Mountain License Application."

6. (MK) I am the former chair of Subcommittee 87-3 on Performance Assessment for the National Council on Radiation Protection and Measurements ("NCRP"). I am also a past member of NCRP Umbrella Scientific Committee 87 on Radioactive and Mixed Waste, and a past member of the National Research Council Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site.

7. (MK) I am a frequent consultant to the International Atomic Energy Agency ("IAEA"), and have supported the governments of Belarus, Bulgaria, Egypt, Estonia, Malaysia, Moldova, Poland, Romania, and the Russian Federation on IAEA missions to site, develop, construct, and analyze disposal facilities to provide national capacity to dispose of radioactive waste. In 2004, I was on the IAEA's International Peer Review Team for the Australian National Repository.

8. (MK) I have conducted recent project work on radioactive waste safety in Korea, Japan, Malaysia, South Africa, and Sweden. In the U.S., I have supported the Environmental Protection Agency ("EPA"), EPRI, Department of Energy ("DOE"), and NRC on a wide variety of radioactive waste disposal and radioactive contamination issues.

9. (MK) I am familiar with the regulatory concept of ALARA, wherein licensees implement procedures and engineering controls based upon sound radiation protection principles to achieve occupational radiation doses and doses to members of the public that are "as low as is reasonably achievable."

1.2 Dr. Michael J. Apted

10. (MA) I am President of Monitor Scientific LLC, Denver, Colorado. My statement of professional qualifications is included with the NEI Petition at Attachment 22.

11. (MA) Monitor Scientific LLC is under contract to NEI to assist it in developing contentions, including NEI-SAFETY-06, "Drip Shields are Not Necessary," for its intervention petition for the construction authorization licensing proceeding for the proposed high-level waste repository at Yucca Mountain, NV pending before the NRC.

12. (MA) I have a Bachelor of Science Degree in Chemistry from the Massachusetts Institute of Technology, and a Ph.D. in Geochemistry from the University of California, at Los Angeles. I have been involved professionally in high-level radioactive waste management and disposal assessment, technology, and regulatory policy for more than 25 years.

13. (MA) I serve as Program Manager for EPRI's oversight of post-closure safety for the proposed repository at Yucca Mountain, and have been associated with EPRI's program for 18 years.

14. (MA) I am co-author of EPRI's independent total system performance assessment reports on Yucca Mountain, including EPRI's postclosure safety assessment code IMARC. I have also co-authored several EPRI studies.

15. (MA) I was a Manager of DOE's Office of Civilian Radioactive Waste Management's ("OCRWM") Performance Assessment Scientific Support ("PASS") Program at Pacific Northwest National Laboratory in the area of design and regulatory compliance for engineered barrier systems.

16. (MA) I am contracted to high-level waste ("HLW") geologic repository implementing and regulatory agencies for the governments of Sweden, Finland, Japan, and South Korea, and have published critical reviews on HLW geological repository studies for both the International Atomic Energy Agency and the Nuclear Energy Agency ("NEA").

17. (MA) I am familiar with the regulatory concept of ALARA, wherein licensees implement procedures and engineering controls based upon sound radiation protection principles to achieve occupational radiation doses and doses to members of the public that are "as low as is reasonably achievable."

1.3 Dr. Fraser King

18. (FK) I am a Principal Consultant and President of Integrity Corrosion Consulting Ltd. My statement of professional qualifications is included with the NEI Petition at Attachment 25.

19. (FK) I am under sub-contract to Monitor Scientific LLC to provide expert advice on engineered barrier system issues for its contract with NEI in assisting NEI to develop contentions for its intervention petition for the construction authorization licensing proceeding for the proposed high-level waste repository at Yucca Mountain, NV pending before the NRC.

20. (FK) I have a Bachelor of Science degree in Chemistry and a Ph.D. in Electrochemistry from Imperial College, University of London, United Kingdom. I have 27 years of experience in the analysis of corrosion and materials issues in the nuclear industry, including 24 years investigating the corrosion behaviour of various metallic alloys proposed as container materials for the isolation of nuclear waste. This work has been carried out for various international radioactive waste repository programs, including those in the U.S., Canada, Finland, Sweden, Japan, Switzerland, and the U.K. In 2007, I was elected a Fellow of the National Association of Corrosion Engineers ("NACE") International. I have published more than 250 journal papers, refereed conference papers, and technical reports in the areas of corrosion science, lifetime prediction, and safety analysis.

21. (FK) I am currently the Technical Leader on containment issues for EPRI's independent analysis of the high-level waste repository at Yucca Mountain. I have responsibility for developing lifetime prediction models for the Alloy 22 waste packages and titanium ("Ti") drip shields, taking into account various corrosion processes, including: uniform corrosion,

localized (crevice) corrosion, stress corrosion cracking ("SCC"), microbiologically influenced corrosion ("MIC"), and hydrogen-induced cracking (for Ti only). I also lead the development of EPRI's commercial spent nuclear fuel alteration model. I have co-authored reports for EPRI on the effect of seismic activity on the structural stability and corrosion behavior of waste packages and am familiar with studies of the likely range of seismic events at the Yucca Mountain repository site.

22. (FK) I am familiar with the regulatory concept of ALARA, wherein licensees implement procedures and engineering controls based upon sound radiation protection principles to achieve occupational radiation doses and doses to members of the public that are "as low as is reasonably achievable."

2. <u>NEI Contention NEI-SAFETY-06</u>

23. (MK, MA, FK) We are familiar with the license application ("LA") filed on June 3, 2008, including the Safety Analysis Report ("SAR"), by DOE for the proposed HLW geologic repository at Yucca Mountain, NV.

24. (MK, MA, FK) We have drafted this Affidavit in support of proposed Contention NEI-SAFETY-06, Drip Shields Are Not Necessary, which reads:

> The drip shields that the Department of Energy ("DOE") proposes as part of the Engineered Barrier System ("EBS") are not necessary because the repository is capable of meeting regulatory requirements with significant performance margin and defense in depth without drip shields. Installation of the drip shields will result in significant and unnecessary radiation exposures, resource use, and costs, and is therefore inconsistent with "as low as is reasonably achievable" ("ALARA") principles.

The basis for Contention NEI-SAFETY-06 reads:

the repository design includes titanium “drip shields” between the waste packages and the repository drift walls to prevent seepage water from dripping onto the waste packages and to protect the waste packages from falling rocks. DOE’s analyses of post-closure performance include several overly conservative assumptions that have led DOE to unnecessarily include drip shields in its repository design, including excessive conservatisms with respect to: (1) the flow rate of water into the drift; (2) the failure rates of waste packages; (3) the robustness of the waste packages to seismic-induced localized corrosion; (4) damage that could occur to a waste package from dynamic impacts from falling rocks; and (5) the damage that could be produced to a waste package from the static loading of rocks built up following a seismic event. In addition, DOE’s analyses take no credit for the performance of the inner stainless steel canister. Without the drip shields, the repository will comply with regulatory requirements with significant performance margin, and little additional performance margin is gained by their installation. The installation of the drip shields will result in significant and unnecessary radiation exposures, and is therefore inconsistent with ALARA principles. Such installation will also result in significant, unnecessary resource and cost expenditures.

25. (MK, MA, FK) This Affidavit provides the factual and technical bases supporting Contention NEI-SAFETY-06. We conclude that DOE should dispense with the installation of drip shields because they are not needed to protect waste packages from seepage and rockfall. The repository without drip shields will comply with regulatory requirements while providing significant performance margin. Their installation will result in little additional performance margin. Dispensing with drip shields will also avoid unnecessary occupational radiation exposures and unnecessary costs.

3. **Statutory and Regulatory Background**

26. (MK, MA, FK) We are aware that the Commission’s regulations at 10 C.F.R. § 63.111 provide, in part, that the geologic repository operations area must meet the requirements of 10 C.F.R. Part 20. We are also aware that the Commission’s regulations at 10 C.F.R. § 20.1002 provide that the regulations in Part 20 apply to persons holding NRC licenses under 10 C.F.R. Part 63.

27. (MK, MA, FK) 10 C.F.R. § 20.1101(b) states that “licensee[s] shall use, to the extent practical, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA).” The Commission’s regulations at 10 C.F.R. § 20.1003 define “ALARA” as “making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.”

4. Summary of LA Provisions Regarding Installation of Drip Shields

28. (MK, MA, FK) LA SAR Section 2.1.1.2 provides that “[t]he drip shield, which will be placed over the waste packages, is fabricated from Titanium Grade 7 (UNS R52400), which is a commercially available, nearly pure titanium alloy containing a small addition of palladium to provide a higher degree of corrosion resistance. The structural components of the drip shield will be constructed using the higher-strength titanium alloy Titanium Grade 29 (UNS R56404), which has alloying elements aluminum and vanadium to provide the required strength, and ruthenium to provide corrosion resistance. This titanium alloy is also highly corrosion resistant in a wide variety of chemical environments.” One drip shield will be placed over each of the thousands of waste packages.

29. (MK, MA, FK) LA SAR Section 2.3.6.2 states that “[t]he purposes of the drip shield are to prevent seepage waters from contacting the waste packages and to protect the waste

package from rockfall." LA SAR Section 2.1.1.2 states that the drip shield is important to waste isolation ("ITWI").

30. (MK, MA, FK) LA SAR Section 1.3.4.7.2 provides that the drip shields will be installed as part of the closure of the repository. More specifically, drip shields will be fabricated and installed during the last 11 years of the 50 year monitoring period after emplacement of the waste packages. OCRWM 2008 at p. 18. At this time, the temperature in the drifts is expected to be suitable for installation of the drip shields. The SAR states that "[t]he air temperatures in the shorter drifts, after 50 years of ventilation, will be at or below the maximum 50°C operating limit for remotely operated equipment." SAR at p. 1.3.4-27.

5. DOE's Analyses of Post-closure Performance Include Several Over-conservatisms that Have Led DOE to Unnecessarily Include Drip Shields in its Repository Design

31. (FK) Over-conservatisms in DOE's analyses of post-closure performance make it unnecessary to include drip shields in its repository design, including over-conservatisms with respect to: (1) the need to divert seepage water away from the waste package; and (2) the need to protect the waste package from rockfall. Both of these over-conservatisms are discussed in detail below. The over-conservatisms in DOE's treatment of the need to divert seepage water include: (1a) the high rate of percolation of water in the repository horizon (which DOE adopted because that rate is specified in a pending proposed rule); (1b) the high rate of water seepage into the drifts; and (1c) the exclusion of the decrease over time in the rate of penetration of localized corrosion of the waste package. The over-conservatisms in DOE's treatment of the need to protect the waste package from rockfall include: (2a) the assumption of very high intensity earthquakes at the repository horizon; (2b) the consequent conservative prediction of the amount of rockfall and the size of rocks ejected from the drift wall; (2c) overestimation of the impact of

seismicity and rockfall on the structural stability of the waste packages because of the assumption of high intensity earthquakes; and (2d) the conservative treatment of the initiation of stress corrosion cracking of the waste packages affected by rockfall.

5.1 Conservatisms in DOE's Analyses with Respect to the Need to Divert Seepage Water Away from Waste Packages

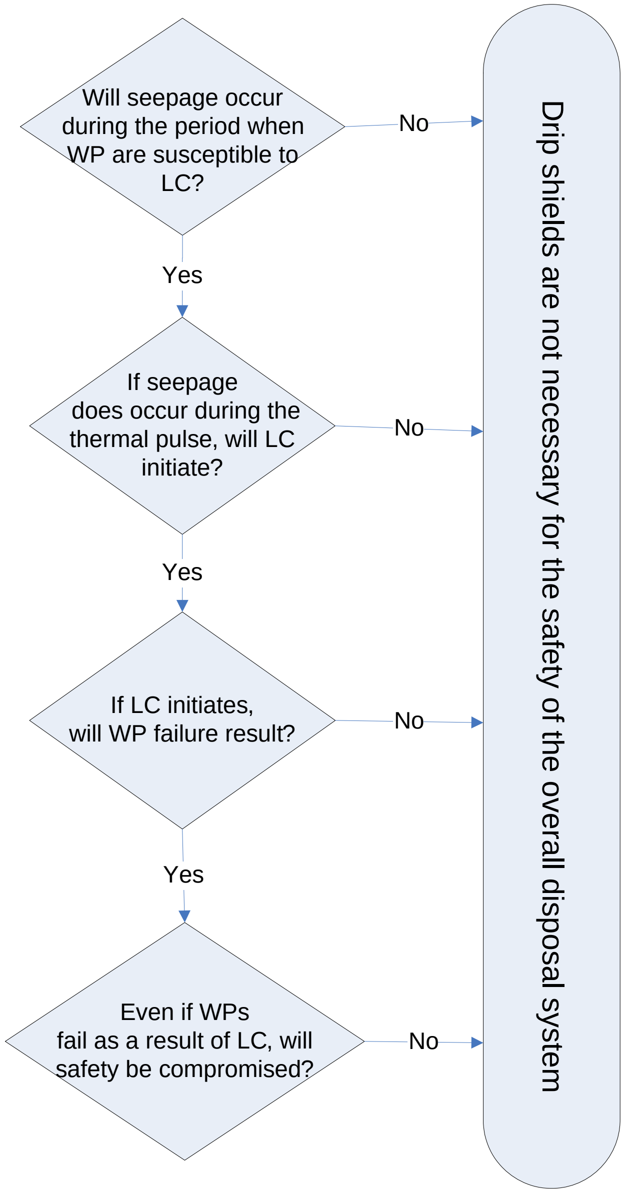
5.1.1 Overview

32. (FK) Figure 1 below shows a decision tree illustrating the important factors associated with the function of the drip shield to protect the waste packages from seepage drips, which, under DOE's conservative analyses, could lead to localized corrosion of and eventually failure of some waste packages. As shown in Figure 1 below, for the drip shield to be a necessary barrier, each of the questions in the decision tree must be answered in the affirmative. If any one of these questions is answered negatively then the failure mechanisms postulated by DOE are not credible and, hence, the drip shield is not necessary. (The abbreviations "LC" and "WP" in Figure 1 mean "localized corrosion" and "waste package" respectively.)

33. (FK) Localized corrosion is only possible during the period of elevated waste package temperature (greater than 100^{o}C) and then only if seepage waters contact the surface of the waste package, a process that the drip shields were designed to prevent. The first necessary process is the seepage of water into the drift during the period of time that the temperature of the waste package is hot enough (i.e., during the initial thermal pulse) to support localized corrosion. Although seepage is considered possible, the amount of seepage water is considered to be significantly less than that assumed by DOE, as outlined below. The second necessary condition is that localized corrosion initiate. It is accepted here that the initiation of localized corrosion could occur if the composition of the seepage water is aggressive (i.e., a high chloride

concentration and a low concentration of inhibitive ions, such as nitrate, sulfate, and bicarbonate). Third, if localized corrosion initiates, it is necessary that it penetrate the waste package if it is to affect the safety of the system. In this regard, it is my opinion that the DOE analysis is overly conservative and ignores processes that will lead to the cessation of this form of corrosion. Fourth, even if one assumes that waste package failure will occur by localized corrosion, the safety of the overall multi-barrier system will not be compromised. Here, again, I believe that the DOE analysis is overly conservative.

Figure 1: Decision Tree for the Function of the Drip Shield to Prevent Seepage Drips from Contacting the Waste Package.



5.1.2 Net Infiltration and Percolation

34. (MK) In the terminology adopted by DOE, net infiltration is the flow rate of water that enters the deep unsaturated zone, and represents the difference between precipitation on the one hand, and runoff, evaporation, and transpiration on the other. Percolation refers to the

flow rate of water that arrives at the repository at depth, and may differ from the net infiltration because of diversion of water in the unsaturated zone above the repository.

35. (MK) The LA has been developed to adhere to the proposed provisions in 10 C.F.R. Part 63, as described in NRC 2005. *See also* 70 Fed. Reg. 53,313 (Sept. 8, 2005). I am aware that the NRC Staff has put forward a draft final rule (NRC 2008), which, if adopted, would not materially alter the conclusions made herein. The LA states that "[t]he proposed rule requires that DOE represent the effects of climate change after 10,000 years by assigning percolation rates at the repository horizon that vary between 13 to 64 mm/yr." LA Section 2.1.2.1, p. 2.1-12. These values are based on an assumption of intermediate/monsoon to "full glacial" climate conditions for the entire duration of the post-10,000 year period. NRC 2005, p. 11. These values are very conservative, both because the time period after 10,000 years will not be glacial for the entire duration, and because the assumed percolation values are very high, given the existence of full glacial conditions. While DOE reasonably decided to adopt these very conservative values from the proposed rule, this aspect of the proposed regulation means that any additional conservatism subsequently imposed by DOE in other analyses (as will be discussed below) based in part on these net infiltration values will result in a severe compounding of the conservatism, because all processes associated with degradation of engineered barriers and the mobilization and transport of radionuclides are dependent on the amount of water entering the repository.

5.1.3 Seepage

36. (MK) The term seepage refers to the flow rate of water into a drift. It differs from the flow in the surrounding rock because a number of phenomena cause water to be diverted around the drift, rather than to flow into it. In the following discussion, two additional terms are

noteworthy. The seepage rate is the rate at which water drips into the drift onto a waste package, and can be expressed in terms of volume of water per unit time per waste package. The seepage fraction is the fraction of waste packages that experience such dripping. The remainder of the waste packages in the repository would not experience dripping water, and would not be subject to advective releases to flowing water. Releases from the non-dripping parts of the repository are extremely low, and provide negligible contribution to the potential peak dose to the reasonably maximally exposed individual ("RMEI") from the repository.

37. (MK) EPRI has estimated that the seepage rate and seepage fraction will be considerably below the estimates currently in use by DOE. EPRI Report 1018058, "Occupational Risk Consequences of the Department of Energy's Approach to Repository Design, Performance Assessment and Operation in the Yucca Mountain License Application," ("EPRI 2008") provides these estimates in Table 1, at p. 6-3 (reproduced below). Although EPRI and DOE employed different mathematical approaches to arrive at their respective values, the DOE mean values are comparable to the EPRI probability weighted values. EPRI 2008, p. 6-3. EPRI has used its seepage model rather than one consistent with DOE's because EPRI believes that DOE's model is overly conservative.

Table 1. Comparison of DOE and EPRI Seepage Fractions and Seepage Rates (Maximum Likelihood Flow Field (DOE) Seepage Case (EPRI); Mean (DOE) or Probability-weighted (EPRI) Net Infiltration). [Sources: DOE/RW-0573, Rev. 0; IMARC-8] Table from EPRI 2008, p. 6-3]

Climate State [DOE/EPRI]	Seepage Fraction (%)		Seepage Rate (kg/yr/WP)*	
	DOE** Mean**	EPRI Probability-weighted Seepage Case***	DOE Mean**	EPRI Probability-weighted Seepage Case***
Present-day/Interglacial	1.1	0.33	1.2	0.50
Monsoon/Greenhouse	2.2	0.33	4.6	0.93
Glacial Transition/Full Glacial Maximum (FGM)	4.7	0.44	14.4	1.9

Notes:
*Averaged over all waste packages.
**10th percentile infiltration scenario (maximum likelihood scenario), Section 2.1.2.1.2, DOE/RW-0573, Rev.0
***Probability-weighed seepage fraction/rate: Base Seepage Case (P=0.96): High Seepage Case (P=0.04)

5.1.4 Localized Corrosion

38. (FK) Localized corrosion is a form of corrosion that occurs in crevices and other occluded regions on the surface and can penetrate the waste package wall at an accelerated rate. DOE analyzes both the initiation and propagation of localized corrosion. LA SAR Section 2.3.6.4.3.1 describes DOE's localized corrosion initiation model. Initiation is assumed to occur if the value of the corrosion potential exceeds (i.e., is more positive than) the value of the crevice re-passivation potential in the same environment. The composition of the seepage water and of the evaporated solution that develops when seepage drips contact hot surfaces also affects the probability of initiation of localized corrosion. Chloride ions are aggressive and increase the probability of initiation. Other ions present in seepage and evaporated waters, such

as nitrate, carbonate, and sulfate, will inhibit localized corrosion and make initiation less likely. Once initiated, the area of localized corrosion is assumed to propagate at a constant rate until complete penetration of the waste package has occurred. LA SAR Section 2.3.6.4.3.2. The propagation rate is assumed to be in the range of 12.7 μm/yr to 1,270 μm/yr, with a median value of 127 μm/yr. This range is based on measurements of the corrosion rate of Alloy 22 in extreme environments, such as concentrated ferric chloride solutions and concentrated hydrochloric acid solutions at elevated temperatures. LA SAR Section 2.3.6.4.2.3. In LA SAR Section 2.3.6.4.3.2, DOE acknowledges that assuming that the crevice, once initiated, will continue to propagate at a constant rate is conservative.

39. (FK) The assumption that, once initiated, localized corrosion propagates at a constant rate greatly overestimates the importance of localized corrosion as a possible failure mode for waste packages made from Alloy 22. Experimental and theoretical evidence demonstrates that the rate of propagation will slow down with time via a physiochemical process referred to as "stifling" (the time-dependent decrease in propagation rate), as acknowledged in LA SAR Section 2.3.6.4.3.2.2. Experimental evidence also demonstrates that the rate of propagation decreases with time according to a power-law growth rate given by the equation $D = k \cdot t^n$, where D is the depth of corrosion, k is a constant that depends on the material and environment, t is time, and n is a time exponent, the value of which is less than 0.5 (the smaller the value of n, the earlier the localized corrosion ceases to propagate). Sandia 2007a, pp. 152-154; He and Dunn 2006, pp. 1-29.

40. (FK) Accounting for the beneficial effect of the stifling of localized corrosion effectively limits the depth to which a propagating crevice will grow. For values of the time

exponent n between 0.1 and 0.5, the effective maximum depth of penetration is less than 5 mm King 2006; Pan et al. 2006. The range of 0.1 to 0.5 is based on a review of values for the time exponent from literature studies of other materials and systems and is deemed an appropriate range for Alloy 22. As a consequence, localized corrosion will not fully penetrate the 25-mm-thick waste package wall and this form of attack will not lead to waste package failure, contrary to the assumptions made by DOE. In EPRI calculations of the lifetime of waste packages over an assessment period of one million years, no failures due to localized corrosion are predicted to occur. EPRI 2005a, pp. B-51 to B-55; King et al. 2008, pp. 59-67. This lack of localized corrosion failures is a consequence of the low probability that seepage water compositions conducive to localized corrosion initiation will be present at Yucca Mountain and the inclusion of the effects of stifling for those few localized corrosion sites that are predicted to initiate.

41. (FK) In summary, DOE unnecessarily concludes that drip shields are necessary to protect the waste packages from seepage water. DOE's analyses are already conservative with respect to the amount of net infiltration it assumes. It then compounds this conservatism by assuming that much greater seepage will occur than is likely to occur. DOE then compounds the conservatism again by assuming that localized corrosion will occur at a much higher rate than is likely. All of these conservatisms taken together result in DOE's conclusion that drip shields are necessary to protect the waste packages from seepage water. Rather, the contrary is true – drip shields are not necessary to protect waste packages from seepage.

5.2 Conservatisms in DOE's Analyses with Respect to the Need to Protect Waste Packages from Rockfall

5.2.1 Overview

42. (MK) As discussed in subsequent paragraphs, DOE erroneously concludes that drip shields are necessary to protect the waste packages from rockfall by compounding several conservatisms in its analyses. DOE overestimates the seismic hazard, which leads to an overestimation of damage to the waste packages from both static and dynamic rockfall loads, as well as an overestimation of waste-package collisions during the event. The overestimation of damage to waste packages leads to an overestimation of stress corrosion cracking of the waste package, an overestimation of waste package failure, and ultimately an underestimation of containment in the engineered barrier system.

43. (FK) Figures 2 and 3 in this Affidavit show decision trees outlining the necessary processes that must occur for rockfall-induced waste package failure by structural/mechanical factors and by stress corrosion cracking to be important to waste isolation. For the drip shield to be a necessary barrier, each of the questions in the decision trees must be answered in the affirmative. If any one is answered negatively, then failure mechanisms postulated by DOE are not credible and, hence, the drip shield is not necessary. (The abbreviation "SCC" in Figure 3 means "stress corrosion cracking;" "WP" means "waste package;" and "WPOB" means "waste package outer barrier.")

5.2.2 Seismicity

44. (MK) Overestimation of the seismic hazard is responsible for subsequent overestimation of a number of effects that influence performance of the repository.

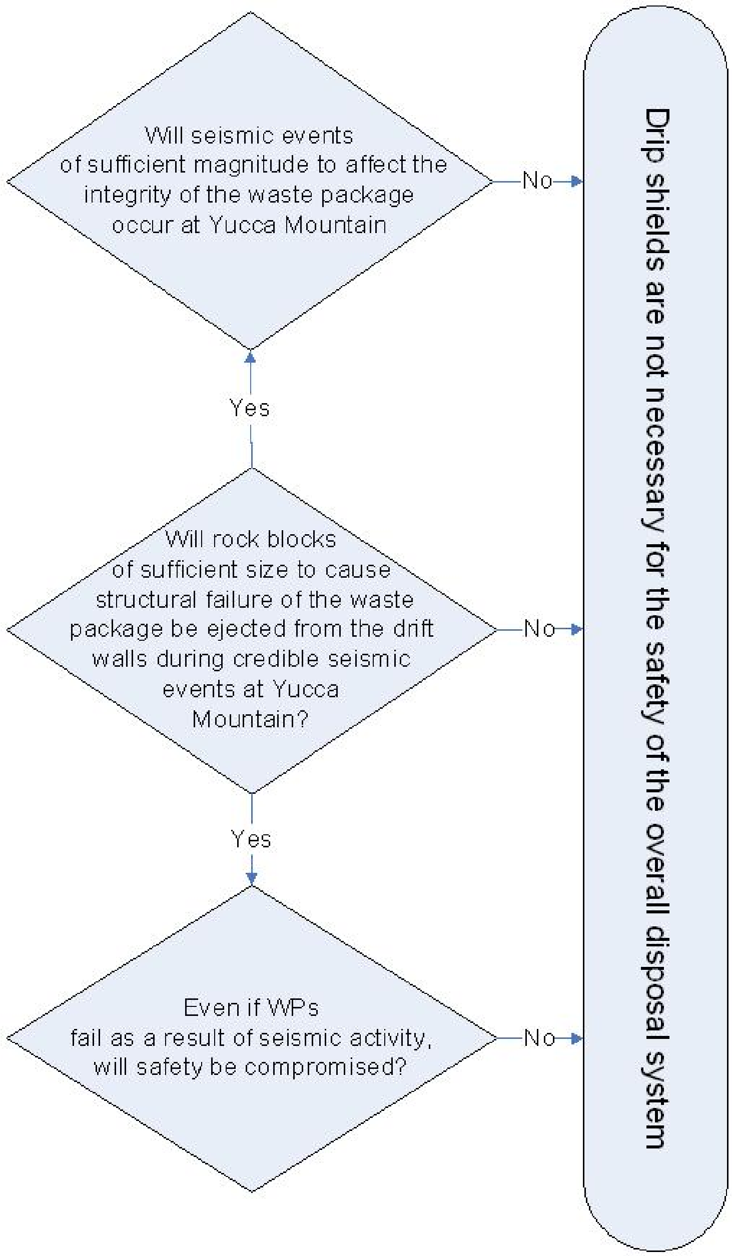
45. (FK) DOE has postulated the future occurrence of very high intensity earthquakes at the repository horizon. These assumptions have been criticized by an independent review panel in 2006: "As an overall and quite general finding – and also as a brief summary of the findings that follow – the Committee finds that there are many lines of evidence and argument that can be drawn from a wide range of geological, geophysical, seismological, and material properties studies that all point to the same general conclusion: at probabilities of exceedance of 10^{-4}/yr and smaller, the seismic hazard at Yucca Mountain as calculated from the 1998 PSHA is too high." Hanks, et al., 2006, page 19.

46. (FK) DOE's M&O contractor's comments on DOE's analysis of seismic ground motions that "[w]hile these ground motions can be used to assess the sensitivity of the response of waste emplacement drifts and engineered barrier system components to such high levels of motions, ultimately results should be evaluated for ground motions that are credible for Yucca Mountain." EPRI 2008, p. 6-6 (quoting BSC 2004). This statement reflects the fact that even the authors of the ground motion assessment at Yucca Mountain believe that their results are too high. This over-conservatism affects the subsequent analyses of the need to protect the waste packages from rockfall.

47. (FK) The decision tree in Figure 2 outlines the necessary processes that must occur for rockfall to cause structural failure of the waste package. The first requirement is that seismic events of sufficient magnitude must occur at Yucca Mountain. DOE's conservative assessment of the magnitude of possible seismic events at Yucca Mountain results in an over-estimate of the credible size of rocks that could be ejected from the drift walls. Second, for rocks of credible size, the kinetic energy of these rocks must be sufficient to puncture or otherwise structurally fail the waste package. Finally, even if a few waste packages do fail because of

impact from large rocks, the safety of the entire repository system may not be compromised if the number of affected waste packages is small or if the remaining natural and engineered barriers provide sufficient containment. In addition to a conservative assessment of structural failure of the waste package by ejected rocks, DOE's analysis of structural failure by seismically-induced vibratory ground motion is also conservative, as discussed below.

Figure 2: Decision Tree for the Function of the Drip Shield to Prevent Rockfall from Causing Structural Failure of the Waste Package



5.2.3 Structural Effects from Seismicity

48. (FK) LA SAR Section 2.3.4 describes the structural degradation of the Engineered Barrier System ("EBS") due to seismic effects and rockfall. The components of the EBS are defined as the emplacement drifts, drip shields, waste packages, waste forms, waste package internals, waste package pallets, and the emplacement drift inverts. DOE examined the structural response of the EBS components for seismic events characterized by peak ground velocities of 0.44 m/s, 1.05 m/s, 2.44 m/s, and 4.07 m/s. LA SAR Section 2.3.4.5. DOE estimates that a seismic event with a peak ground velocity of 4 m/s could occur once every one million years. The extent of degradation, damage, and failure [defined in LA SAR Section 2.3.4.1, p. 2.3.4-8] of the EBS depends on the peak ground velocity, with degradation, damage, and failure increasing with increasing velocity. By using a conservative range of possible peak ground velocities, DOE overestimated the impact of seismic events on waste package failure.

49. (FK) EPRI considers the probability of waste package failure by vibratory ground motion and rockfall to be lower than that predicted by DOE for two reasons: (i) the expected peak ground velocities are significantly lower than those considered by DOE, and (ii) DOE's treatment of immediate structural failure of the waste packages and delayed failures by stress corrosion cracking is overly conservative. The effects of vibratory ground motion and of dynamic impacts from rockfall on structural failure of the waste package are considered here. The effect of delayed waste package failure by stress corrosion cracking due to rockfall-induced residual tensile stress is considered in the next section. EPRI 2005b, pp. 5-1 to 5-22, 12-1 to 12-9, 13-1 to 13-3; EPRI 2006, pp. 4-1 to 4-8, 5-1 to 5-15; EPRI 2008, pp. 6-1 to 6-19.

50. (FK) Based on an analysis of the expected activity of the Solitario Canyon Fault, the closest and most-active source in the region of Yucca Mountain, EPRI concluded that the likely magnitude of seismic events would be smaller than that assumed by DOE. EPRI 2008, pp. 6-5 to 6-8. EPRI considers a peak ground velocity of 2 m/s to be a conservative estimate of the maximum velocity at Yucca Mountain for a return period of 10^6 years, and a peak ground velocity of 0.75 m/s to be representative of the velocity for a return period of 10^5 years.

51. (FK) EPRI considered the structural response of the waste package to an impact with an unyielding surface at velocities of 4 m/s (EPRI 2005b, pp. 5-1 to 5-13) and 2 m/s and 0.75 m/s. EPRI 2006, pp. 4-1 to 4-8. For a flat-on impact at 2 m/s, no plastic deformation of the waste package shell occurred and, hence, no tensile residual stress developed. EPRI 2006, pp. 4-1 to 4-8; EPRI 2008, pp. 6-8 to 6-9. If the waste package impacts the unyielding surface at an oblique angle of 4^o with a velocity of 2 m/s, plastic strain is predicted to develop around part of the edge of the closure lid (equivalent to an arc of $15\text{-}30^o$). For an oblique impact at a peak ground velocity of 0.75 m/s (characteristic of a return period of 10^5 years), minor plastic strain is predicted to develop over a small area of the edge of the outer lid (less than 15^o arc). EPRI 2006, pp. 4-6 to p. 4-7.

52. (FK) EPRI considered the effect of a large rock block ejected from the wall of the emplacement drift impacting an "aged" waste package with a reduced wall thickness of 20 mm (to simulate loss of part of the wall thickness through corrosion). EPRI 2005b, pp. 12-1 to 12-9. The rock block that EPRI modeled was assumed to have a mass of 7.49 metric tons with a volume of 3.11 m^3. EPRI concluded that the waste package shell would not deform plastically, so that the shell would neither tear nor experience residual tensile stress that could subsequently lead to the initiation of stress corrosion cracks.

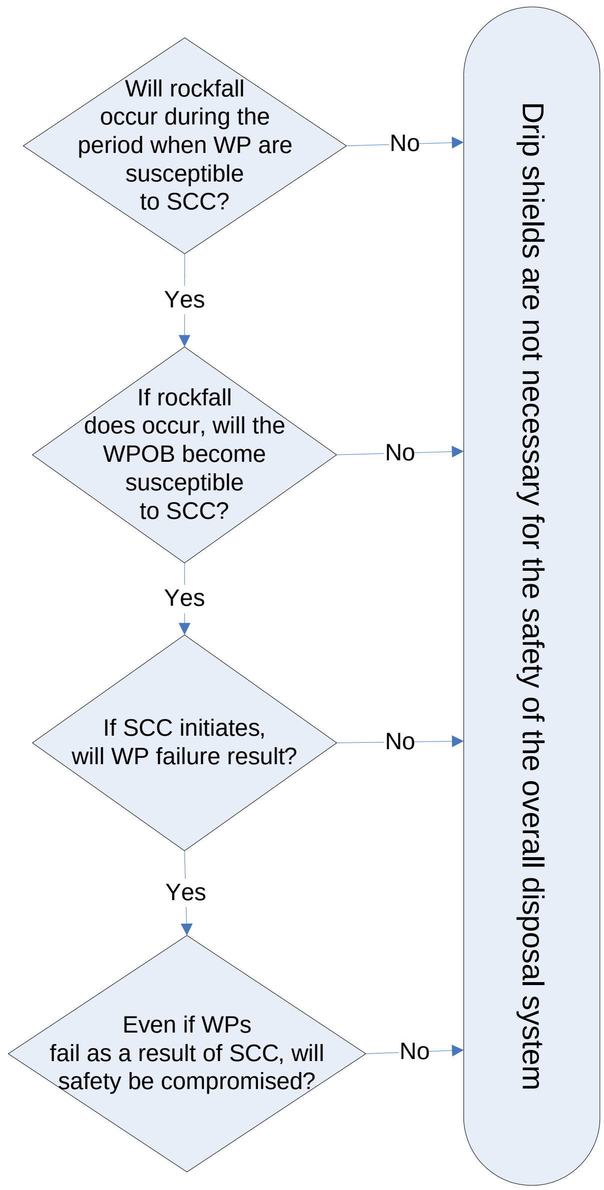
53. (FK) In summary, EPRI's analyses indicate that the drip shield is not required to protect the waste package from structural damage from rockfall. Furthermore, the waste packages are structurally robust under a range of postulated seismic-induced scenarios.

5.2.4 Stress Corrosion Cracking on Alloy 22 Waste Packages

54. (FK) One of the mechanisms by which waste packages may fail as a result of seismic activity is stress corrosion cracking of Alloy 22 in areas where a residual tensile stress greater than the threshold value is induced by the associated vibratory ground motion or rockfall.

55. (FK) The decision tree in Figure 3 outlines the necessary processes that must occur for rockfall-induced waste package failure by SCC to be important to waste isolation. The first prerequisite for rockfall-induced SCC is that rocks either impact or accumulate on the waste package surface as a result of seismic activity. DOE's conservative assessment of the magnitude of possible seismic events at Yucca Mountain results in an over-estimate of the amount of rockfall in the drifts. Second, initiation of SCC requires that three criteria be met: (1) the tensile residual stress imparted by the rock impacts or accumulated rock pile exceed a threshold value; (2) the seepage water composition must be supportive; and (3) the electrochemical corrosion potential must exceed a threshold value. DOE conservatively ignores the latter two in its analysis. Third, if SCC initiates, the crack must propagate entirely through the wall for waste package failure to occur. It is conservatively assumed here that, once initiated, an SCC crack will propagate to failure. Fourth, even if a few waste packages do fail by SCC, the safety of the entire repository system may not be compromised if the number of affected waste packages is small or if the remaining natural and engineered barriers provide sufficient containment.

Figure 3: Decision Tree for the Function of the Drip Shield to Prevent Rockfall from Damaging the Waste Package Leading to Stress Corrosion Cracking Failures



56. (FK) By assuming a higher range of peak ground velocities than that which will be experienced at Yucca Mountain, DOE inevitably overestimates the amount of damage (defined by the DOE as the creation of areas of residual tensile stress sufficiently high to initiate stress corrosion cracking, LA SAR Section 2.3.4.1) that the waste package will suffer as a

consequence of seismic activity and the associated rockfall. Notwithstanding the overestimation of the amount of damage to the waste package, the DOE treatment of the subsequent development of stress corrosion cracks is also conservative and overestimates the number of waste packages that will experience through-wall cracks.

57. (FK) LA SAR Section 2.3.6.5.1 (pp. 2.3.6-45 to 2.3.6-54) describes the experimental basis and model abstraction used in the LA for stress corrosion cracking of the waste package. Stress corrosion cracking can result from rockfall or seismic-induced residual tensile stresses. In the absence of a pre-existing crack-like defect, initiation of stress corrosion cracking on smooth surfaces (e.g., on the waste package body) is assumed to occur if the stress exceeds a threshold stress that is a fraction of the at-temperature yield strength. LA SAR Section 2.3.6.5.3.2. If a crack initiates, or if an existing crack-like defect exists, then the crack is assumed to propagate if the stress intensity factor exceeds a threshold value. Crack propagation is then estimated using a slip dissolution model.

58. (FK) According to DOE, the only criterion for the initiation of stress corrosion cracking on a smooth surface is that the residual tensile stress should exceed the threshold stress of 90-105% of the yield stress. LA SAR Section 2.3.6.5.3.2.

59. (FK) The assumption that the only criterion required for initiation of stress corrosion cracking on smooth surfaces is that the stress exceed a threshold value overestimates the probability of crack initiation. In addition to the need to exceed a threshold stress, two other criteria must be met: (i) the composition of the aqueous environment must be supportive of stress corrosion cracking, and (ii) the corrosion potential of the waste package must be sufficiently positive. The corrosion potential is the natural electrochemical potential adopted by the surface

of the waste package in the repository or of corrosion samples in the laboratory and, in corrosion science, has been shown to be related to the probability of various corrosion phenomena, including stress corrosion cracking. Experimental evidence shows that stress corrosion cracking of smooth Alloy 22 specimens only occurs in certain types of water and at sufficiently positive electrochemical potentials. Sandia 2007b, pp. 6-11 to 6-13. In fact, stress corrosion cracking was only observed at potentials more positive than the corrosion potential of the specimens – an observation that is supported by the absence of stress corrosion on samples that are not polarized to more-positive potentials. Sandia 2007b, pp. 6-7 to 6-13. By excluding consideration of the dependence of stress corrosion cracking initiation on the nature of the solution and the electrochemical potential, DOE overestimates the probability of crack initiation.

60. (FK) Comparison of the composition of possible seepage waters at Yucca Mountain with those shown to cause stress corrosion cracking of smooth specimens in the laboratory indicates that only ~70% of waters will support crack initiation. EPRI 2005a, pp. B-19 to B-25; King and Kolar 2006, pp. 481-483; King et al. 2008, pp. 59-67. These waters tend to be alkaline and are characterized by the Simulated Concentrated Water defined by DOE. EPRI 2005a, Table B-2.

61. (FK) EPRI also considered the effect of electrochemical potential on crack initiation. EPRI 2005a, Appendix B.3.2.3. Crack initiation on smooth specimens was only observed by DOE if the potential of the specimen was equal to or more positive than +200 mV_{SSCE} – a potential that is several hundred millivolts more positive than the corrosion potential of Alloy 22 in the cracking environments. Sandia 2007b, Table 6-2. EPRI developed a method to account for this dependency of crack initiation on electrochemical potential based on a triangular distribution of threshold potentials for cracking with a minimum value of 0 V_{SSCE} and

a peak value of +0.4 V_{SSCE} and the upper 99.994 percentile of predicted corrosion potentials of the waste package. EPRI 2005a, Appendix B.3.2.3. If the effect of electrochemical potential on crack initiation is accounted for, only 2.4% of the waste packages which are exposed to both an appropriate aqueous environment and sufficient tensile stress will experience stress corrosion cracking, EPRI 2006, p. 5-4, compared with 100% of waste packages in the conservative DOE analysis. LA SAR Section 2.3.6.5.1 (pp. 2.3.6-45 to 2.3.6-54).

62. (FK) Overall, therefore, the DOE stress corrosion model significantly overestimates the number of waste packages that will experience the initiation of stress corrosion cracking by a factor of ~50 by excluding consideration of the effects of the environment and electrochemical potential.

5.2.5 <u>The Number of Waste Package Failures Induced by Rockfall is Small Compared to Other Failure Initiators</u>

63. (FK) EPRI has analyzed the effects of seismicity and rockfall on the failure of waste packages in the effective absence of drip shields (the drip shields were assumed to be displaced during the first of the multiple seismic events considered). EPRI 2006, Chapter 5. A series of ten seismic events was considered, starting at a time of 50,000 years and occurring every 100,000 years thereafter, each with a peak ground velocity of 0.75 m/s. Waste package failure was considered to result from impact of the waste package with other EBS components due to vibratory ground motion, dynamic impact by large ejected rock blocks, or by stress corrosion cracking as a result of tensile stress imparted by an accumulated rock pile.

64. (FK) Based on the structural analyses described above, no waste package failures were predicted to occur due to impacts with EBS components for the assumed peak ground

velocity of 0.75 m/s, which EPRI considers to be the appropriate peak ground velocity for a seismic event with a return period of 10^5 years. EPRI 2006, pp. 4-6 to 4-7.

65. (FK) The number of waste packages that failed due to large ejected rock blocks was estimated for each seismic event based on an analysis of the rock strength and response of the rock to the seismic event. A total of 18 waste packages (out of 11,000) were predicted to fail by this mechanism over a 10^6-year period. EPRI 2006, pp. 5-1 to 5-15.

66. (FK) The number of waste packages that failed due to stress corrosion as a result of an accumulated rock pile was estimated based on the time-dependent amount of rockfall and the stress corrosion initiation criteria defined above. Based on structural analyses, it was estimated that a rock pile 10m or greater in height would be sufficient to induce residual tensile stress greater than 90 - 100% of the temperature-dependent yield stress – the threshold stress criterion used by EPRI. EPRI 2005a, Appendix B.3.2.3. Based on the additional requirement that a suitable environment be present to support cracking, only 70% of the waste packages subjected to a rock pile equal or greater than 10m in height were judged to be susceptibile to stress corrosion. Furthermore, of those waste packages with a sufficiently high rock pile and suitable environment, only 2.4% were judged to exceed the threshold potential criterion for crack initiation, as discussed above, compared with 100% for the DOE approach to predicting SCC.

67. (FK) The net result of these analyses for the repeat-seismic event was that only an additional 64 waste package failures were predicted, over and above those that failed by other non-seismic-related corrosion processes. Of this total of 64, 18 were the result of dynamic impacts by large rock blocks and 46 were the result of stress corrosion cracking due to an accumulated rock pile. To put this number of additional waste package failures into context,

EPRI concluded that on the order of 1200 waste package failures were predicted to have occurred due to other corrosion processes after 10^6 years for the waste package design considered. EPRI 2006, Section 5.3.2. Therefore, the number of rockfall-induced waste package failures avoided by the use of a drip shield is small (a total of 64) compared with the total number of failures by all other corrosion and mechanical processes (a total of approximately 1200).

6. <u>DOE Takes No Credit for The Performance of The Inner Stainless Steel Canister</u>

68. (MA) DOE has conservatively assumed that the stainless steel Transport, Aging, and Disposal canister will not act as a barrier to radionuclide release. LA SAR Section 2.4.2.2.1.2.2.1, p. 2.4-66. DOE should take credit for this function.

69. (MA) Failure to take credit for the barrier function offered by the TAD canister places more responsibility on the drip shield and other EBS components, unnecessarily inflating the apparent importance of the drip shield as a barrier.

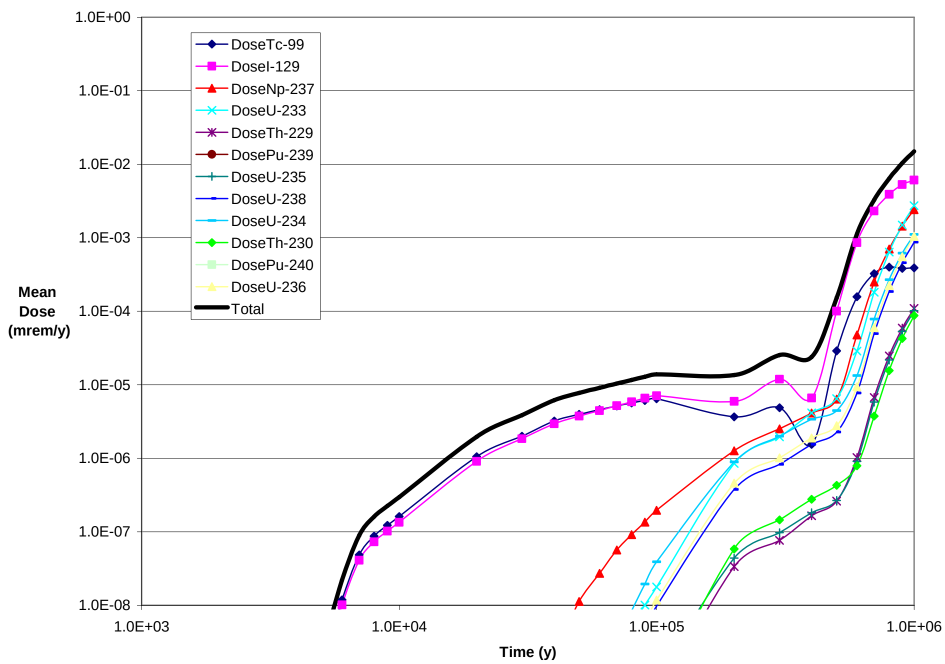
7. <u>Without Drip Shields, the Repository Will Comply with Regulatory Requirements with Significant Performance Margin, and Negligible Additional Performance Margin is Gained by the Installation of Drip Shields</u>

70. (MA) EPRI showed Total System Performance Assessment ("TSPA") consequences of the drip shields by carrying out calculations assuming that the drip shields are present and assuming that they are absent. EPRI 2008, p. 6-18. These results are shown below in Figures 4(a) and 4(b). The nominal results, assuming the presence of the drip shield, are shown in Figure 4(a). The doses prior to 100,000 years after closure are entirely the result of an assumed juvenile failure associated with manufacturing defects. (Briefly, a juvenile failure is a through wall penetration due to manufacturing-induced or handling-induced defects at a time

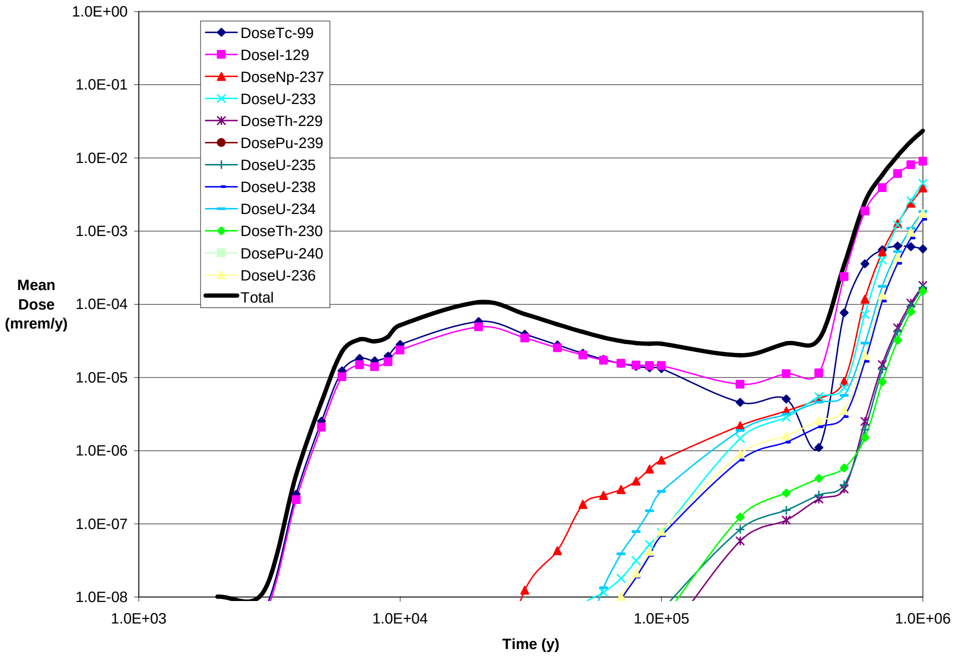
earlier than would be predicted by mechanistic degradation models for a defect-free waste package). This assumed juvenile failure is itself a conservatism, as the expected value for the number of initially failed waste packages is less than 1. The first failure of a waste package from degradation occurs at about 400,000 years after closure.

71. (MA) The results of a sensitivity analysis in which the drip shields are assumed to be absent is shown in Figure 4(b). As EPRI noted (EPRI 2008, p. 6-17) there is a moderate increase in doses at early times associated with the waste package that is assumed to be initially failed due to manufacturing defects, but the change in peak dose without the presence of the drip shields is negligible.

Figure 4. Comparison of EPRI's Base Case (a) and No Drip Shield (b) TSPA Results



4(a)



4(b)

8. Installation of Drip Shields will Result in Significant and Unnecessary Radiation Exposures, Resource Use, and Costs

72. (MK) EPRI relied on DOE's own estimate for the dose rate to a worker during drip shield installation to estimate a total dose of 975 person-rem if the installation takes place over a period of ten years. EPRI 2008, p. B-10. The DOE estimate was derived in BSC 2007, and represents exposures assuming five (5) shifts of two (2) workers per shift needed for the drip shield emplacement. BSC 2007, p. 20. Installation of drip shields was assumed to involve specified amounts of time spent by the workers in particular locations in the repository during drip shield installation. These locations are (1) North Portal Access Control Station, 300 task hours per year; (2) General Access Main, 1650 hours per year; and (3) Access Mains near the emplacement drift turnout, 50 hours per year. BSC 2007, Table 6, p. 19. Drip shields will be installed using an electrically powered and remotely operated Drip Shield Emplacement Gantry.

BSC 2007, p. 32. The total 975 person-rem estimate provided in BSC 2007 does not take into account the potential for off-normal operating conditions that may lead to higher exposures than baseline conditions. The radiation exposures from normal or off-normal conditions would not be incurred if drip shields were not installed.

73. (MK) The Final Supplemental Environmental Impact Statement ("FSEIS") estimates that the manufacture and installation of drip shields will require over fifty thousand tons of titanium over a ten year period. See FSEIS Table 4-36, p. 4-108. The use of these resources would be avoided if drip shields were not installed.

74. (MK) A direct estimate of the life-cycle cost of drip shield acquisition, manufacture, and installation does not appear in extant DOE documentation supporting the LA. However, by examining overall cost estimates, it is possible to arrive at an approximate estimate. DOE's "Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program, Fiscal Year 2007" (OCRWM 2008) provides future cost estimates for "Waste Package & Drip Shield Fabrication" in year-2007 dollars during three phases of repository activities. OCRWM 2008 at Tables 2-3, 2-4 & 2-5, pp. 17-18. During the first phase – Repository Engineering, Procurement, and Construction, years 2007-2053 – DOE estimates that Waste Package & Drip Shield Fabrication will cost $200 million (in 2007 dollars). This first phase will include "only the initial procurements" of the disposal waste packages. In other words, little (if any) of these costs result from the fabrication and installation of drip shields. OCRWM 2008, p.17. During the second phase – Repository Emplacement Operations, years 2017-2073 – DOE estimates that Waste Package & Drip Shield Fabrication will cost $12.58 billion (in 2007 dollars). However, most (if not all) of this cost will result from the fabrication of 17,450 waste packages. In other words, this cost includes little, if any, expenditure for the

fabrication and installation of drip shields. During the third phase – Repository Monitoring, years 2074-2123 – DOE estimates that Waste Package and Drip Shield Fabrication will cost $7.63 billion (in 2007 dollars). This cost includes fabrication and emplacement of drip shields during the last ten years of this phase – but would include little, if any, expenditures for waste package fabrication. This is because the Repository Monitoring period occurs after SNF-filled waste packages are emplaced in the repository. Accordingly, it is likely that most (if not all) of the $7.63 billion (in year 2007 dollars) estimated for Waste Package and Drip Shield Fabrication during years 2074-2123 will be for drip shields. This analysis is confirmed by the "Annual Cost Profile" provided in Figure B-1 and Table B-1 (pp. B-1 to B-6), which estimates that repository annual expenditures will increase from approximately $50 million to approximately $750 million for the 11 year period from 2113-2123. The approximately $700 million increase in annual expenditures during this period comports with DOE's proposal to emplace drip shields "during the last 10 years of the [repository monitoring] phase," which runs from 2074 to 2123. OCRWM 2008, p. 18. These costs would be avoided if drip shields were not installed.

9. <u>Conclusion</u>

75. (MK, MA, FK) Without the drip shields, the repository will comply with regulatory requirements with significant performance margin, and negligible additional performance margin is gained by the installation of drip shields. Installation of the drip shields will result in significant and unnecessary radiation exposures, resource use, and costs, and is therefore inconsistent with ALARA principles.

Dr. Matthew Kozak

Sworn and subscribed to before me this 16 day of Dec 2008.

Notary Public
My Commission expires: 10-19-09

NOTARY PUBLIC
STATE OF COLORADO

Dr. Michael Apted

Sworn and subscribed to before me this 16 day of Dec 2008.

Notary Public
My Commission expires: 10.19.09

Fraser King

Dr. Fraser King

Witnessed only as to execution.
No legal advice sought or given.

Sworn and subscribed to before me this 18 day of December 2008.

Notary Public
My Commission expires: n/a

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Nanaimo, B.C. V9R 3E1

References

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ATTACHMENT 14

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

<u>BEFORE THE COMMISSION</u>

In the Matter of	)	
U.S. DEPARTMENT OF ENERGY (High-Level Waste Repository)	)	Docket No. 63-001

<u>AFFIDAVIT OF BRIAN GUTHERMAN, THOMAS E. MAGETTE, AND RICHARD A. LOFTIN IN SUPPORT OF PROPOSED CONTENTION NEI-NEPA-01</u>

Brian Gutherman ("BG"), Thomas E. Magette ("TM"), and Richard A. Loftin ("RL"), being duly sworn, state as follows:

1. <u>Introduction</u>

1.1 <u>Brian Gutherman</u>

1. (BG) I am Vice President of Advanced Concepts, Inc. ("ACI") of Scottsdale, Arizona. My statement of professional qualifications is included with the NEI Petition at Attachment 17.

2. (BG) ACI is under contract to the Nuclear Energy Institute ("NEI") to assist NEI in developing contentions, including NEI-NEPA-01, "Inadequate NEPA Analysis for 90% TAD Canister Receipt Design," for its intervention petition for the construction authorization licensing proceeding for the proposed high-level waste repository at Yucca Mountain, Nevada pending before the Nuclear Regulatory Commission ("NRC" or "Commission").

3. (BG) I earned a Bachelor of Science degree in Mechanical Engineering from Rutgers University in 1982, graduating with high honors. I have been involved professionally in

nuclear power plant design, licensing, operation, and regulatory policy for more than 26 years, the last ten of which have focused on commercial spent nuclear fuel (“SNF”) storage and transportation.

4. (BG) I serve as President of ACI Nuclear Energy Solutions, a New Jersey-based division of ACI with responsibility for the company’s spent fuel management consulting business. I have been working in this capacity for ACI for two years.

5. (BG) I assist nuclear power plant owners in implementing dry spent fuel storage at onsite Independent Spent Fuel Storage Installations (“ISFSIs”); perform third-party assessments of ISFSI operations; and provide spent fuel management consulting services to NEI.

6. (BG) From 2004 to 2006, I worked as a private consultant in the nuclear energy field with a focus on ISFSI implementation, spent fuel management, and spent fuel storage and transportation cask licensing.

7. (BG) From 1998 to 2004, I was the licensing manager for Holtec International, a spent fuel storage and transportation cask designer. I was responsible for managing the company’s efforts to acquire and amend NRC 10 C.F.R. Part 71 and 10 C.F.R. Part 72 certificates of compliance for its spent fuel cask product line.

8. (BG) In my capacity as a consultant to NEI, I track the storage of commercial SNF in the United States, including the type of storage system technology used by the fuel owners and whether these systems are licensed for storage under 10 C.F.R. Part 72, transportation under 10 C.F.R. Part 71, or both. I track the quantity of commercial SNF stored in spent fuel pools and in ISFSIs at each site and in each state. I estimate how much commercial

SNF is permanently discharged from each reactor every year, and predict future trends for dry SNF storage. I monitor the licensing status of domestic SNF storage and transportation casks, including initial certifications and amendments thereto.

9. (BG) I have reviewed and am familiar with the Department of Energy's ("DOE") Transport, Aging, and Disposal ("TAD") canister specification.

1.2 Thomas E. Magette

10. (TM) I am the Senior Vice President, Business Development for the Commercial Services Group of Energy*Solutions* of Washington, DC, which provides a wide variety of services to the nuclear power industry, including waste packaging, processing, transportation, and disposal; liquid waste processing; decontamination and decommissioning; cask design and production; and spent fuel management. My statement of professional qualifications is included with the NEI Petition at Attachment 26.

11. (TM) I hold BS and MS degrees in Nuclear Engineering from the University of Tennessee. I have 29 years of experience managing and conducting environmental assessment, siting, nuclear safety, and public outreach programs for a wide variety of energy generation, transmission, and defense facilities. I have managed more than 50 National Environmental Policy Act ("NEPA") projects for several Federal agencies, including more than a dozen environmental impact statements ("EIS") prepared for DOE. While in a previous position with Tetra Tech, I served as the Program Manager for a DOE-wide NEPA contract for 7 years.

12. (TM) I have had extensive experience in all phases of environmental compliance for energy facilities, and management of quality, schedule, and cost controls for large multi-disciplinary projects and programs. I have prepared and presented expert testimony in regulatory

proceedings. I have managed the response to more than 100,000 public comments received as part of NEPA reviews for several highly controversial projects, including the siting and licensing of power plants, defense nuclear reactors, nuclear weapons manufacturing facilities, radioactive waste processing and disposal facilities, high-voltage transmission lines, bio-hazard facilities and natural gas distribution lines.

13. (TM) I am a registered Professional Engineer in Maryland, Virginia, and New Mexico.

1.3 <u>Richard A. Loftin</u>

14. (RL) I am a Senior Engineer, Nuclear Fuel Services, for Southern Nuclear Operating Company, Inc. My statement of professional qualifications is included with the NEI Petition at Attachment 18.

15. (RL) I earned a Bachelor of Science degree in Nuclear Engineering from Mississippi State University in 1974, and have conducted post-graduate work in Mechanical Engineering at the University of Alabama, Birmingham. I have been involved professionally in nuclear power plant design, licensing, construction, engineering, and operation, for more than 30 years, the last eleven of which have focused on commercial spent nuclear fuel ("SNF") storage and related issues. In my current position, I provide support to three nuclear plant sites (a total of six reactor units) for fuel inspections of new and spent nuclear fuel, and dry cask loading. My prior experience includes work offloading spent fuel from a reactor core, fuel shuffle within a reactor core, and reloading new nuclear fuel into reactor cores. I am currently the primary contact and interface at Southern Nuclear Operating Co. with all fuel vendors for site inspection services, other Southern personnel, and industry peers for all nuclear fuel related issues and

questions and participate on industry committees that concern spent nuclear fuel dry storage issues and casks, and the proposed geologic repository at Yucca Mountain. Based on my many years of experience with spent nuclear fuel related issues, I am very familiar with the spent nuclear fuel dry cask loading and unloading processes and the radiation exposures that result from such activities.

2. <u>Proposed Contention NEI-NEPA-01</u>

16. (BG, TM, RL) We are familiar with the license application ("LA"), including the General Information Section, Safety Analysis Report ("SAR"), filed on June 3, 2008 by DOE for the proposed HLW geologic repository at Yucca Mountain, NV, and the accompanying Final Supplemental Environmental Impact Statement ("FSEIS").

17. (BG, TM, RL) We have drafted this Affidavit in support of Proposed Contention NEI-NEPA-01, "Inadequate NEPA Analysis for 90% TAD Canister Receipt Design," which reads:

> The Yucca Mountain Final Supplemental Environmental Impact Statement ("FSEIS") fails to analyze reasonably foreseeable environmental impacts that will result from DOE's proposal to receive up to 90% of spent nuclear fuel ("SNF") at Yucca Mountain in Transport, Aging, and Disposal ("TAD") canisters.

The basis for Contention NEI-NEPA-01 reads:

> The Yucca Mountain License Application ("LA") states that the repository surface facilities are designed to receive at least 90% of commercial SNF at the repository in TAD canisters (loaded at reactor sites). This will result in some commercial SNF already loaded into dual-purpose canisters ("DPCs") and transportable bare fuel casks ("BFCs") being unloaded and reloaded into TAD canisters at reactor sites. The Department of Energy's ("DOE's") FSEIS fails to analyze the environmental impacts from having to unload DPCs and BFCs and reload TAD canisters at reactor sites, including the additional low-level radioactive waste that will result from the discarded DPCs and BFCs, and the

environmental impacts associated with transporting the discarded DPCs and BFCs.

18. (BG, TM, RL) This Affidavit provides the factual and technical bases supporting Contention NEI-NEPA-01. We will demonstrate that DOE has failed to analyze the environmental impacts from having to reload canisters at reactors sites, and that the FSEIS should be amended to include this analysis.

3. Statutory and Regulatory Background

19. (BG, TM, RL) We are aware that the Commission's regulations at 10 C.F.R. § 63.21(a) require that DOE prepare an environmental impact statement in accordance with the Nuclear Waste Policy Act of 1982, as amended, which must accompany the safety analysis report. We are also aware that 10 C.F.R. § 63.24(c) requires that DOE supplement its EIS in a timely manner so as to "take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts," and that 10 C.F.R. § 63.41(e) requires that "[a]ll applicable requirements of part 51 of this chapter have been satisfied."

20. (BG, TM, RL) 10 C.F.R. § 51.67, "Environmental information concerning geologic repositories," states:

> (a) In lieu of an environmental report, the Department of Energy, as an applicant for a license or license amendment pursuant to part 60 or 63 of this chapter, shall submit to the Commission any final environmental impact statement which the Department prepares in connection with any geologic repository developed under Subtitle A of Title I, or under Title IV, of the Nuclear Waste Policy Act of 1982, as amended. (See § 60.22 or § 63.22 of this chapter as to the required time and manner of submission.) The statement shall include, among the alternatives under consideration, denial of a license or construction authorization by the Commission.

> (b) Under applicable provisions of law, the Department of Energy may be required to supplement its final environmental impact statement if it makes a substantial change in its proposed action that is relevant to environmental concerns or determines that there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts. The Department shall submit any supplement to its final environmental impact statement to the Commission.

21. (BG, TM, RL) 10 C.F.R. §51.45, Environmental report, subparagraph (b)(1), requires that the ER discuss "[t]he impact of the proposed action on the environment. Impacts shall be discussed in proportion to their significance."

4. <u>Summary of LA Provisions Regarding the Repository's Non-TAD SNF Design Capability</u>

22. (BG, TM, RL) LA General Information Section 1.2.2, Routine Operations, states at p. 1-16: "The [Geologic Repository Operations Area] surface facilities have been designed to support a mostly canistered waste stream. A TAD canister is utilized for commercial SNF assemblies. The repository objective is to have 90% of individual commercial SNF assemblies loaded into TAD canisters by the utilities with a limited quantity of uncanistered individual commercial SNF assemblies and dual-purpose canisters requiring handling in a pool (i.e., submerged). In some cases, commercial SNF will require aging before it is ready for emplacement."

23. (BG, TM, RL) LA SAR Section 1.5.1.1, Commercial SNF, at p. 1.5.1-8, states that "[t]he majority of commercial SNF assemblies will be shipped to the repository in TAD canisters. The TAD canisters are transferred directly into a waste package for disposal or into an aging overpack for aging. Commercial SNF assemblies that cannot be placed into TAD canisters at utility sites can be handled and shipped to the repository in transportation casks certified by the NRC or in DPCs. Commercial SNF assemblies shipped in a cask or DPC, once received at

the repository, may be either loaded into an aging overpack and sent to the aging pad or opened and transferred into a TAD canister before being placed into a waste package . . . . In each year of operation, the repository shall be capable of accepting, transporting, and disposing of commercial SNF where at least 90% is received in TAD canisters and no more than 10% is received as uncanistered assemblies."

5. DOE's Proposal Requires Some Non-TAD SNF to be Re-packaged into TAD Canisters at Reactor Sites Prior to Shipment to Yucca Mountain

24. (BG) Although DOE has designed the repository surface facilities to receive at least 90% of commercial SNF in TAD canisters, more than 10% of the total repository allotment for commercial SNF is already stored in DPCs and transportable BFCs. The number of DPCs and transportable BFCs loaded at reactor sites will continue to increase until TAD canisters are available for use by the reactor operators.

25. (BG) Section 114(d) of the Nuclear Waste Policy Act, as amended, limits the first geologic repository's capacity to 70,000 metric tons of heavy metal ("MTHM") until a second repository is operational. The term MTHM includes the category Metric Tons of Uranium ("MTU") found in uranium oxide-based SNF and MTU of other heavy metals found in SNF and high-level waste. MTHM is used here for consistency with the Nuclear Waste Policy Act and the Yucca Mountain LA and FSEIS.

26. (BG) Section 1.4.2 of the Yucca Mountain Repository FSEIS, Proposed Approach to Disposal, states at p. 1-14, "[t]he materials DOE would dispose of under the Proposed Action include about 63,000 MTHM of commercial spent nuclear fuel and high-level radioactive waste…." The 63,000 MTHM commercial SNF estimate takes into account the

amount of DOE SNF and high level waste that also must be disposed of in the repository (see FSEIS Table 3-20, p. 3-101), while still meeting the overall 70,000 MTHM limit.

27. (BG) Thus, under DOE's proposed scenario whereby no more than 10% of commercial SNF would be received at Yucca Mountain in DPCs and transportable BFCs, no more than 6,300 MTHM can be received at Yucca Mountain in non-TAD canisters and transportable BFCs.

28. (BG) I estimate that, as of June 2008, approximately 11,721 MTHM of commercial SNF was in dry ISFSI storage in the United States. Twenty-five (25) MTHM of this fuel is stored in modular ventilated storage at the Fort St. Vrain site. Thus, approximately 11,696 MTHM of commercial SNF is in dry storage in casks or canisters as of June 2008. This amount is broken down into the following types of storage:

1. Fuel in non-transportable bare fuel casks: 293 MTHM;
2. Fuel in Part 71-licensed transportable bare fuel casks: 482 MTHM;
3. Fuel in bare fuel casks designed to be transportable, but not yet Part 71-licensed: 1,272 MTHM;
4. Fuel in non-transportable canisters: 1,957 MTHM;
5. Fuel in Part 71-licensed DPCs: 6,156 MTHM.
6. Fuel in canisters designed to be DPCs, but not yet licensed for transportation: 1,535 MTHM.

29. (BG) Thus, I estimate that 6,638 MTHM of commercial SNF is currently being stored in BFCs licensed for transportation (482 MTHM) and DPCs licensed for transportation (6,156 MTHM). This amount exceeds the 10% non-TAD SNF limitation of 6,300 MTHM of

commercial SNF that DOE intends to receive at the Yucca Mountain repository in transportable BFCs and DPCs.

30. (BG) I expect that reactor sites will continue to load SNF into DPCs and transportable BFCs prior to the availability of DOE's TAD canister system and prior to the opening of a high-level waste repository at Yucca Mountain, which, if approved, is estimated to occur in 2020 at the earliest.

31. (BG) As TAD canisters are not yet commercially available, I have assumed, based on the current schedule for TAD development, that DPCs will continue to be loaded at reactor sites at least through the end of 2012, per DOE's expectation that TAD canister designs will be licensed and made available for SNF storage in 2013.

32. (BG) Based on the last three years of data, I estimate that an amount of SNF equal to approximately 50% of SNF permanently discharged from reactor cores each year will go into dry storage at reactor sites. SNF that is discharged from a reactor initially goes into a spent nuclear fuel pool. Depending on how much room is available in the pool, some other, older SNF is moved into dry storage in order to accommodate the SNF freshly discharged from the reactor. My estimate that an amount of SNF equal to approximately 50% of SNF permanently discharged from reactor cores each year will go into dry storage at reactor sites is a conservatively low estimate because I expect that the percentage will increase in the future as more plants run out of wet storage space in their spent fuel pools. Indeed, I have read and am familiar with EPRI 2008, Feasibility of Direct Disposal of Dual Purpose Canisters in a High-Level Waste Repository, August 2008. Therein, EPRI assumes that the equivalent of approximately 77% of commercial

SNF permanently discharged each year (1,700/2,200 MTHM) will go into ISFSI storage each year between now and 2020 (EPRI 2008, p. 2-3).

33. (BG) Under my assumption that an amount of SNF approximately equal to 50% of SNF permanently discharged from reactor cores each year will go into dry storage at reactor sites, an additional 5,169 MTHM of commercial SNF will go into dry storage at reactor sites between July 2008 and the end of 2012. I estimate that at least 95%, or 4,908 MTHM, of this SNF will be stored in DPCs and transportable BFCs.

34. (BG) As previously discussed, 1,272 MTHM SNF is stored in BFCs designed to be transportable, but not yet Part 71-licensed; and 1,535 MTHM SNF is stored in DPCs not yet licensed for transportation. In my opinion, it is likely that these casks and canisters will be licensed for transportation by the time of Yucca Mountain estimated opening in 2020. Therefore, it is likely that the 2,807 MTHM (1,272 MTHM + 1,535 MTHM) stored in these casks and canisters will be able to be transported to Yucca Mountain.

35. (BG) Thus, by the time Yucca Mountain is expected to open in 2020, I estimate that at least 14,354 MTHM of commercial SNF (consisting of 6,638 MTHM currently stored in DPCs and transportable BFCs, 4,908 MTHM that will be stored in DPCs and transportable BFCs through the end of 2012, and 2,807 MTHM stored in DPCs and BFCs that will be licensed by 2020) will reside in transport-licensed DPCs and BFCs in the United States.

36. (BG) This amount is 8,054 MTHM more than the amount of commercial SNF DOE intends to receive at the repository in other than TAD canisters as stated in the LA – 10% or 6,300 MTHM of commercial SNF. Thus, under DOE's 90% TAD receipt strategy, at least 8,054 MTHM of commercial SNF will have to be unloaded from DPCs and transportable BFCs

and re-loaded into TAD canisters at reactor sites or elsewhere before it arrives at the Yucca Mountain repository. Because I am not aware of any alternative locations for the unloading and reloading to occur, I assume that the unloading and reloading will occur at reactor sites.

37. (BG) My estimate that at least 8,054 MTHM of commercial SNF will have to be re-loaded into TAD canisters from DPCs and transportable BFCs at reactor sites is conservative. Should the availability of TAD canisters be delayed beyond 2013, utilities will continue to load DPCs and transportable BFCs. Indeed, I estimate that for each year the TAD program is delayed, an additional 1,042 MTHM SNF will be put into transportable dry storage (approximately, 75 DPCs and 5 BFCs) based on the SNF that is discharged from reactors and placed into dry storage, and the small portion of the SNF in dry storage that will likely be stored in non-transportable canisters/casks.

38. (BG) In summary, I estimate that there will be at least 14,354 MTHM of commercial SNF loaded in DPCs and transportable BFCs at reactor sites by 2020, which exceeds DOE non-TAD receipt design by 8,054 MTHM. This number is a conservative estimate and could increase depending on variables such as the amount of SNF discharged from reactors and placed into dry storage and when TAD canisters become available.

6. **<u>DOE's Proposal Will Create an LLRW Stream, Which Will Have to be Transported and Disposed</u>**

39. (BG) Based upon my estimate that there will be at least 8,054 MTHM of commercial SNF loaded in DPCs and transportable BFCs at reactor sites by 2020 in excess of DOE's 10% non-TAD receipt design, and assuming on average that 13 MTHM SNF are stored in each DPC or BFC, the SNF from approximately 620 DPCs and BFCs will have to be unloaded

from DPCs and BFCs and reloaded into TADs at reactor sites. This would result in 620 discarded DPCs and BFCs.

40. (RL) DOE acknowledges that the discarded DPCs and BFCs will be low-level radioactive waste ("LLRW"), which would require processing, handling, and disposal or recycling. See FSEIS at Section 2.1.2.3.4.

41. (TM) Furthermore, where there is a current disposal option, the discarded BFCs and DPCs would be transported by utilities to a site for disposal. There currently are three LLRW disposal facilities for commercial LLRW. These are located in Richland, WA, Barnwell, SC, and Clive, UT. The Clive, UT facility is open to waste from any generator, but that site can only accept Class A waste. The Richland site accepts Classes A, B, and C LLRW generated only in two LLRW compacts: the Rocky Mountain Compact (Nevada, Colorado, and New Mexico) and the Northwest Compact (Washington, Oregon, Idaho, Montana, Wyoming, Utah, Alaska, and Hawaii). The Barnwell site accepts Classes A, B, and C LLRW only from generators within the Atlantic Compact (New Jersey, Connecticut, and South Carolina). Thus, any waste generated from the repackaging of waste into TADs (not only the DPCs and BFCs, but other ancillary LLRW) would have to be shipped to one of these locations, to the extent that the LLRW is from an eligible state.

42. (RL) To the extent that the LLRW is Class A, the LLRW could be disposed at the Clive, UT facility. But not all of the LLRW will necessarily be Class A LLRW, which means that, unless the reactor is located in a state that has access to an operating LLRW disposal facility, there will be no current disposal option for the waste.

7. DOE Has Failed to Analyze the Environmental Impacts of the LLRW Transportation and Disposal

43. (TM) None of the FSEIS sections dealing with canister repackaging operations mention that DOE has shifted the LLRW disposal and LLRW transportation burdens to the reactor sites.

44. (TM) Thus, DOE has failed to account for the impacts of the increased volume of LLRW for disposal. The FSEIS does not account for the disposal of the DPCs and BFCs and waste generated in the repackaging process. It is likely that some of the DPCs and BFCs will not qualify as Class A waste. There will be no disposal site for any such waste that is generated in a state that does not have access to either the Barnwell or Richland LLRW disposal sites. While it is possible that DPCs and BFCs may be decontaminated and recycled, DOE has not analyzed the occupational dose and disposal of the associated LLRW generated by the decontamination process.

45. (TM) DOE has also failed to account for impacts from the transportation of waste generated from onsite repackaging. The LLRW generated in the process of repackaging waste from DPCs and BFCs into TADs must eventually be transported to one of the commercial LLRW disposal facilities. DOE has not analyzed the impacts of transporting this waste in the FSEIS.

46. (TM) Further, DOE has failed to analyze the fact that utilities' alternatives for LLRW disposal have greater environmental impacts than DOE's alternatives for LLRW disposal. The FSEIS states that DOE LLRW will go to the Nevada Test Site ("NTS") LLRW disposal facility or some commercial site. FSEIS at Section 4.1.12.1. LLRW generated at utility sites can only go to one of three commercial sites. If they can ship the LLRW offsite for

disposal, some utilities may be restricted in their choice of disposal sites due to their Compact status.

47. (TM) Furthermore, as noted above, it is not a given that the discarded DPCs and BFCs will be Class A LLRW. In this case, utilities outside the Atlantic, Northwest, and Rocky Mountain compacts will have no disposal option available for non-Class A LLRW. It further is possible that the DPCs and BFCs could have transuranic contamination of sufficient levels that they could not be classified as LLRW, and thus would have no disposal site regardless of the state in which the reactor is located. DOE has failed to analyze these possibilities.

48. (TM) In any event, even if the utilities can dispose of the 620 discarded DPCs and BFCs, the transportation impacts from waste generated at the reactor sites will be greater than those generated by re-canistering at Yucca Mountain. DOE can readily dispose of LLRW generated at Yucca Mountain at NTS, which is immediately adjacent to Yucca Mountain, while nuclear utilities would have to ship waste to a commercial LLRW site, a distance of as much as 2,600 miles.

49. (TM) DOE has also neglected to analyze costs associated with its 90% TAD receipt scenario. Transporting and disposing of the LLRW that will result from repackaging SNF from DPCs and BFCs into TADs will pose an additional cost burden on utilities, which DOE has failed to consider.

8. <u>Conclusion</u>

50. (BG, TM, RL) DOE fails to analyze the environmental impacts and costs from the LLRW waste that will be generated, and transportation of that LLRW, because of DOE's proposed action to accept 90% TAD canisters at Yucca Mountain. The FSEIS should be amended to include such analysis.

Brian Gutherman

Sworn and subscribed to before me this 13th day of December 2008.

MEREDITH PEASE EASTERLY
NOTARY PUBLIC
STATE OF NEW JERSEY
MY COMMISSION EXPIRES AUGUST 17, 2011

Notary Public
My Commission expires: 8-17-11

Thomas E. Magette

Sworn and subscribed to before me this 15 day of December 2008.

Notary Public
My Commission expires: March 15, 2011

Richard Loftin

Sworn and subscribed to before me this 15th day of December 2008.

Notary Public Gail A. Hicks
My Commission expires: July 5, 2010

STATE OF Alabama
COUNTY OF Jefferson
Commissioned in Bibb County

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ATTACHMENT 15

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

	)	
In the Matter of	)	
	)	
U.S. DEPARTMENT OF ENERGY	)	Docket No. 63-001
(High-Level Waste Repository)	)	
	)	
	)	
	)	

AFFIDAVIT OF BRIAN GUTHERMAN IN SUPPORT OF PROPOSED CONTENTION NEI-NEPA-02

Brian Gutherman, being duly sworn, states as follows:

1. Introduction

1. I am Vice President of Advanced Concepts, Inc. ("ACI") of Scottsdale, Arizona. My statement of professional qualifications is included with the NEI Petition at Attachment 17.

2. ACI is under contract to the Nuclear Energy Institute ("NEI") to assist NEI in developing contentions, including NEI-NEPA-02, "Overestimate of Number of Truck Shipments," for its intervention petition for the construction authorization licensing proceeding for the proposed high-level waste repository at Yucca Mountain, Nevada pending before the Nuclear Regulatory Commission ("NRC" or "Commission").

3. I earned a Bachelor of Science degree in Mechanical Engineering from Rutgers University in 1982, graduating with high honors. I have been involved professionally in nuclear power plant design, licensing, operation, and regulatory policy for more than 26 years, the last ten of which have focused on commercial spent nuclear fuel ("SNF") storage and transportation.

4. I serve as President of ACI Nuclear Energy Solutions, a New Jersey-based division of ACI with responsibility for the company's spent fuel management consulting business. I have been working in this capacity for ACI for two years.

5. I assist nuclear power plant owners implement dry spent fuel storage at onsite Independent Spent Fuel Storage Installations ("ISFSIs"), perform third-party assessments of ISFSI operations, and provide spent fuel management consulting services to NEI.

6. From 2004 to 2006, I worked as a private consultant in the nuclear energy field with a focus on ISFSI implementation, spent fuel management, and spent fuel storage and transportation cask licensing.

7. From 1998 to 2004, I worked as the licensing manager for Holtec International, a spent fuel storage and transportation cask designer. I was responsible for managing the company's efforts to acquire and amend NRC 10 C.F.R. Part 71 and 10 C.F.R. Part 72 certificates of compliance for their spent fuel cask product line.

8. In my capacity as a consultant to NEI, I track the storage of commercial SNF in the United States, including the type of storage system technology used by the fuel owners and whether these systems are licensed for storage under 10 C.F.R. Part 72, transportation under 10 C.F.R. Part 71, or both. I track the quantity of commercial SNF stored in spent fuel pools and in ISFSIs on each site and in each state. I estimate how much commercial SNF is permanently discharged from each reactor every year, and predict future trends for dry SNF storage. I monitor the licensing status of domestic SNF storage and transportation casks, including initial certifications and amendments thereto.

9. I have reviewed and am familiar with the Department of Energy's ("DOE's") Transport, Aging, and Disposal ("TAD") canister specification.

2. NEI Contention NEI-NEPA-02

10. I am familiar with the license application ("LA") filed on June 3, 2008 by the DOE for the proposed spent fuel and high-level waste geologic repository at Yucca Mountain, Nevada and the associated Final Supplemental Environmental Impact Statement ("FSEIS").

11. I have drafted this Affidavit in support of proposed NEI Contention NEI-NEPA-02, "Overestimate of Number of Truck Shipments," which reads:

> The Yucca Mountain Final Supplemental Environmental Impact Statement ("FSEIS") overestimates the radiological exposures that reactor and Yucca Mountain site workers will receive because it overestimates the number of spent nuclear fuel ("SNF") shipments to Yucca Mountain that will occur by truck.

The basis for Contention NEI-NEPA-02 reads:

> FSEIS Table G-10 overestimates the number of truck shipments of commercial SNF to Yucca Mountain and therefore underestimates the number of rail shipments that will be required to ship commercial SNF to Yucca Mountain. A more realistic estimate of shipping would result in greater reliance on rail shipping, a lower number of truck shipments, and therefore fewer overall shipments. Thus, DOE overstates the radiation exposure to workers at Yucca Mountain and reactor sites.

My Affidavit provides the factual and technical bases supporting Contention NEI-NEPA-02. I will demonstrate that DOE's assumption of 2,646 truck shipments from commercial nuclear power plants overestimates – by 1,481 shipments – the number of shipments to the Yucca Mountain repository, resulting in an overestimate of radiation exposure to plant workers who prepare the spent fuel transportation packages for shipment.

3. Statutory and Regulatory Background

12. I am aware that the Commission's regulations at 10 C.F.R. § 63.21(a) require that DOE prepare an environmental impact statement ("EIS") in accordance with the Nuclear Waste Policy Act of 1982, as amended, which must accompany the safety analysis report. I am also aware that 10 C.F.R. § 63.24(c) requires that DOE supplement its EIS in a timely manner so as to "take into account the environmental impacts of any substantial changes in its proposed actions or any significant new circumstances or information relevant to environmental concerns bearing on the proposed action or its impacts," and that 10 C.F.R. § 63.41(e) requires that "[a]ll applicable requirements of part 51 of this chapter have been satisfied."

13. 10 C.F.R. § 51.67, "Environmental information concerning geologic repositories," states:

> (a) In lieu of an environmental report, the Department of Energy, as an applicant for a license or license amendment pursuant to part 60 or 63 of this chapter, shall submit to the Commission any final environmental impact statement which the Department prepares in connection with any geologic repository developed under Subtitle A of Title I, or under Title IV, of the Nuclear Waste Policy Act of 1982, as amended. (See § 60.22 or § 63.22 of this chapter as to the required time and manner of submission.) The statement shall include, among the alternatives under consideration, denial of a license or construction authorization by the Commission.
>
> (b) Under applicable provisions of law, the Department of Energy may be required to supplement its final environmental impact statement if it makes a substantial change in its proposed action that is relevant to environmental concerns or determines that there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts. The Department shall submit any supplement to its final environmental impact statement to the Commission.

14. 10 C.F.R. §51.45, Environmental report, subparagraph (b)(1) requires that the ER discuss "[t]he impact of the proposed action on the environment. Impacts shall be discussed in proportion to their significance."

4. Summary of DOE Proposed Action

15. Table G-10 of the FSEIS indicates that commercial spent fuel will be shipped exclusively by truck from nine sites across the country. Two of these sites, Idaho National Laboratory and Hanford Site, are operated by DOE and will not be discussed further. The remaining seven sites are non-DOE commercial nuclear power plant sites. Those sites, the fuel type to be shipped – Pressurized Water Reactor ("PWR") assemblies or Boiling Water Reactor ("BWR") assemblies, and the number of truck cask shipments estimated are listed below:

- Crystal River (PWR): 280 shipments
- Turkey Point (PWR): 577
- Clinton (BWR): 327
- Pilgrim (BWR): 344
- Cook (PWR): 768
- Ginna (PWR): 313
- LaCrosse (BWR): 37

16. DOE uses this group of truck shipments to estimate the impacts on workers and members of the public from the transportation of spent fuel and high-level radioactive waste to the Yucca Mountain repository. Specifically, sections G.5 through G.9 of the FSEIS discusses the impacts of incident-free transportation, accidents, sabotage, and other events based on the fraction of spent fuel transported by rail versus by truck to the repository. Tables G-22 through G-66 of the FSEIS provide the radiological and non-radiological impacts on a state-by-state basis, for 44 states and the District of Columbia (the remaining six states have neither spent fuel or high-level waste nor proposed transportation routes). Because DOE overestimates the number

of truck shipments, the environmental impacts of loading commercial SNF for shipment to the Yucca Mountain repository summarized in the FSEIS are incorrect.

5. **<u>DOE Estimates A Significantly Higher Amount of Commercial SNF to be Shipped from Reactors in Truck Casks Than will Actually Occur</u>**

17. The FSEIS does not explain the basis for the plants chosen or the number of truck shipments in the FSEIS. Indeed, DOE's truck shipment estimate was challenged as being too high in a comment on the draft SEIS. *See* Comment Response Document, Section 1.6.2.2 (Comment RRR000620/0011). DOE responded that its estimate of truck shipments is based on the latest *Facility Interface Data Survey* (DIRS 175677 – Gillespie 2005, all). DOE further states that, over time, the capability of generators to ship by rail may change and that fewer truck shipments would result in a corresponding decrease in impacts. *Id.*

18. It is public knowledge that commercial SNF from at least six of the seven plants listed in FSEIS Table G-10 will be placed in dry storage at on-site ISFSIs in dual-purpose canisters ("DPCs"), which are designed to be shipped in rail cask-sized shipping packages weighing approximately 125 tons each. Therefore, commercial SNF from these plants will likely be shipped to the Yucca Mountain repository by rail, not by truck. These plants are: Crystal River, Turkey Point, Pilgrim, Cook, Ginna and LaCrosse. The extent to which heavy-haul trucks (or barges) may be used to ship commercial SNF from these plants will be limited to short-distance transportation of the rail-sized shipping package to a nearby rail head for inter-modal transfer and shipment by rail to the Yucca Mountain repository.

19. Of the 2,319 truck shipments estimated above for these six plants, 1,938 shipments would contain PWR fuel and 381 shipments would contain BWR fuel. If that fuel actually is transported to the repository by rail, the number of shipments and associated radiation

dose to workers preparing the shipments will be substantially less than those estimated in the FSEIS, as described below.

6. <u>Commercial SNF from These Six Plants Will Be Transported by Rail, which Will Require Fewer Overall Shipments</u>

20. It is not clear whether the DOE will accept this commercial SNF in DPCs or if it will have to be reloaded into TAD canisters, which are also designed to be shipped by rail, given DOE's objective to receive at the repository 90% of commercial SNF in TAD canisters. For the purposes of this contention, it is conservatively assumed that the number of rail shipments is based on the capacity of the TAD canister design, which is less than the capacity of DPCs, resulting in a higher number of rail shipments than if shipment of DPCs were assumed. The TAD canister has a design capacity of 21 PWR assemblies or 44 BWR assemblies, compared to a typical DPC capacity of 32 PWR assemblies or 60-plus BWR assemblies.

21. The estimated total number of assemblies predicted to be discharged during the licensed life from each of the six plants is shown below. To assure that a bounding value is calculated, it is assumed that all plants except LaCrosse (which is permanently shut down) extend their operating licenses for 20 years.

- Crystal River: 2,262 PWR assemblies
- Turkey Point: 4,426 PWR assemblies
- Pilgrim: 5,262 BWR assemblies
- Cook: 6,299 PWR assemblies
- Ginna: 1,910 PWR assemblies
- LaCrosse: 333 BWR assemblies

22. The above totals are 14,897 PWR assemblies and 5,595 BWR assemblies.

23. The number of TAD canisters required to ship the fuel from each of these plants to Yucca Mountain can be calculated simply by dividing the number of assemblies by the capacity of the canister to be used (21 for PWR fuel and 44 for BWR fuel),

1. Crystal River: 108 TAD canisters
2. Turkey Point: 211 TAD canisters
3. Pilgrim: 120 TAD canisters
4. Cook: 300 TAD canisters
5. Ginna: 91 TAD canisters
6. LaCrosse: 8 TAD canisters

24. Therefore, the same amount of fuel estimated in the FSEIS to require 2,319 truck shipments would require 838 rail cask-size TAD canisters, or a difference of 1,481 packages to be prepared for shipment and a difference of 1,481 packages to be received at the repository.

7. Fewer Packages to Prepare for Shipment Means Less Worker Radiation Dose

25. Table G-2 of the Yucca Mountain FSEIS provides DOE's estimate of 0.432 person-rem of worker radiation exposure to load each batch of uncanistered SNF into a truck cask and load the truck cask onto a truck trailer at reactor sites. Thus, the total radiation worker dose to load 2,319 truck casks is approximately 1,000 person-rem using DOE's dose values.

26. Table G-2 of the Yucca Mountain FSEIS provides DOE's estimate 0.663 person-rem of worker radiation exposure to transfer a TAD canister from storage, load into a rail cask, and load the rail cask onto a rail car at reactor. Thus, the total radiation worker dose to load 838 rail cask-size shipping packages is estimated to be 555 person-rem.

27. Accordingly, the FSEIS overestimates dose to workers at reactor sites by approximately 445 person-rem.

28. The FSEIS does not provide similar radiation dose information for the receipt and handling of truck casks and rail casks at the repository. According to my analysis, 838 rail cask-size TAD canisters, rather than 2,319 truck shipments, will be received at the repository. In my opinion, the difference in radiation dose for the handling and preparation of truck casks and rail casks at reactor sites would likely be comparable to the difference in radiation dose for the receipt and handling of truck casks and rail casks at the repository.

8. <u>Conclusion</u>

29. DOE overestimates the radiation dose to reactor site workers ship fuel from the Crystal River, Turkey Point, Pilgrim, Cook, Ginna, and LaCrosse plants to the Yucca Mountain repository by at least 445 person-rem because of its erroneous assumption that all fuel from these plants will be shipped by truck to the repository. This overestimate would be even higher if it was assumed that higher-capacity DPC-based shipping packages were used to ship this same amount of commercial SNF to Yucca Mountain. Further, DOE overestimates the dose that would be received by repository site workers because of the overestimate of truck shipments received at the repository. Thus, DOE overstates the expected environmental impact from the repository.

Brian Gutherman

Sworn and subscribed to before me this 13th day of December 2008.

Notary Public

My Commission expires: 8-17-11

MEREDITH PEASE EASTERLY
NOTARY PUBLIC
STATE OF NEW JERSEY
MY COMMISSION EXPIRES AUGUST 17, 2011

ATTACHMENT 16

MATTHEW W. KOZAK, Ph. D.

EDUCATION

- University of Washington, Seattle, WA: Ph. D. in Chemical Engineering, 1988
- Cleveland State University, Cleveland, OH: B.S. in Chemical Engineering, 1981

PROFESSIONAL HISTORY

- Monitor Scientific, LLC, Denver, CO, Principal Consultant, 1999-Current
- QuantiSci, Inc. (formerly Intera Information Technologies Inc.), Environmental Systems Assessment Group, Denver, CO, Principal Staff Consultant 1995-1999
- Sandia National Laboratories, Technical Staff, Albuquerque, NM**,** Senior Member, 1989-1995
- Standard Oil (Ohio) Research, Warrensville Heights, OH**,** Research Engineer, 1981-1983
- Harshaw Catalyst Research, North Randall, OH**,** Summer Intern, 1980
- Mill-Rose Laboratories, Mentor, OH, Research Consultant, 1980

AFFILIATIONS AND AWARDS

- Member of Health Physics Society
- Member of the Society for Risk Analysis
- Member of American Nuclear Society
- Member of American Institute of Chemical Engineering

REPRESENTATIVE EXPERIENCE

- Over twenty years of experience in environmental and engineering research and development, and in application of safety assessment and risk assessment techniques for radioactive, hazardous, and mixed waste disposal.
- Over eighteen years in technical management of multiple projects on safety assessment of near-surface radioactive waste disposal facilities, dose assessment of residual radioactive contamination in soils and buildings, and computer code development.
- Member of the International Review Team for the safety assessment of the Australian National Repository, 2004.
- Member (and past chair) of National Council on Radiation Protection and Measurements (NCRP) Committee 87-3 on Performance Assessment of Radioactive Waste Disposal Facilities (1991-2005).
- Member of NCRP Umbrella Scientific Committee 87 on Radioactive and Mixed Waste (1991-2004).
- Member of the National Academy of Science, National Research Council Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site (2000-2001).
- Official U.S. delegate to the International Atomic Energy Agency's Coordinated Research Program on Improvement of Safety Assessment Methodologies (ISAM), 1997-2000. Member of the Coordinating Committee for ISAM, and leader of the Safety Cases Working Group.
- International Expert Missions on safety assessment, regulatory analysis, and licensing of near-surface radioactive waste disposal facilities to Australia, Belarus, Bulgaria, Egypt, Estonia, Malaysia, Moldova, and Poland, sponsored by the International Atomic Energy Agency.

- Development of the USNRC performance assessment methodology for low-level waste in accordance with requirements in 10 CFR Part 61.
- Eight years of research experience in surface and colloid science, with special application to analysis of electrokinetic phenomena in porous media and concentrated suspensions.

REPRESENTATIVE PROJECTS

Dr. Kozak has been employed by Monitor Scientific LLC and its progenitors since January 1995. During that time, he has provided technical support to numerous clients in the areas of safety assessment of both near-surface and geological radioactive waste disposal facilities, regulatory development, dose assessment for residual contamination of soils and buildings, toxic materials risk assessment, and mixed waste issues.

Electric Power Research Institute
Dr Kozak conducts research for the Electric Power Research Institute in developing improved approached for conducting safety assessments for the proposed Yucca Mountain high-level waste repository. This work has involved software development and management for groundwater releases from the repository, and an independent evaluation of the effects of an igneous event on the repository.

International Clientele
Dr. Kozak has also supported a number of international clients on both low-level and high-level waste repository evaluations, and remedial action sites. Recent project work has focused on programs in Canada, Japan, Korea, South Africa, Sweden, and the UK. This work has included site-specific assessments, regulatory development, generic modeling, and technical review.

Environmental Protection Agency
Dr. Kozak has supported the U.S. Environmental Protection Agency (EPA) in a variety of technical areas. He has led the technical team developing the basis for acceptance of radionuclides at RCRA-C disposal facilities. He also provided technical support for the licensing regulation for the proposed Yucca Mountain high-level radioactive waste repository. Additional areas of support to EPA have included evaluations of radionuclides in sewage sludge, spent source analysis, and evaluation of mixed waste minimally contaminated with radioactivity.

National Committees
Dr. Kozak chaired Scientific Committee 87-3 for the National Council on Radiation Protection (NCRP) from 1991-2002. NCRP Scientific Committee 87-3 had the goal of providing national guidance to resolve issues associated with safety assessment of radioactive waste disposal facilities. Dr. Kozak was also a member of NCRP Umbrella Scientific Committee 87 on Radioactive and Mixed Waste. Dr. Kozak was also a member of the National Research Council Committee on Cesium Processing Alternatives for High-Level Waste at the Savannah River Site (2000-2001).

I*AEA Activities*
Dr. Kozak is a frequent consultant to the International Atomic Energy Agency. He has been to Bulgaria, Egypt, Estonia, Malaysia, Moldova, Poland, and Romania on missions to site, develop, construct, and analyze disposal facilities to provide national capacity to disposal of radioactive waste. He also has completed an IAEA Expert Mission to Belarus, during which risks were evaluated, associated with waste disposals of Chernobyl-contaminated wastes. Dr Kozak was the official U.S. delegate to the IAEA's Coordinated Research Program on Improvement of Safety Assessment Methodologies (ISAM). He was a member of the Coordinating Committee for ISAM, and leader of the Safety Cases Working Group. He is currently participating in the subsequent program, ASAM (Application of Safety Assessment Methodologies) as a technical advisor for the reassessment and regulatory working groups.

Sandia National Laboratories
During his tenure as Senior Member of the Technical Staff at Sandia National Laboratories, Dr. Kozak led numerous projects on radioactive and mixed wastes. His principal responsibilities were to lead projects in the areas of low-level waste, residual contamination, and Below-Regulatory Concern waste for the NRC. Dr. Kozak was also the principal technical leader of an Inter-Regional Short Course on safety assessment of near-surface disposal facilities, which was jointly sponsored by IAEA and the NRC. While at Sandia, Dr. Kozak also participated in the International Transport Model Validation (INTRAVAL) exercise as a U.S. Participant.

Dr. Kozak was a member of the U.S. Department of Energy's Research and Development Task Team (RDTT), which has been established to identify research needs to improve near-surface waste disposal practices throughout the DOE complex. Dr. Kozak was invited to participate in this effort despite not being associated with a DOE disposal facility because of his international reputation in near-surface disposal.

He supported the U.S. Nuclear Regulatory Commission (NRC) in their development of a safety assessment methodology for near-surface radioactive waste disposal facilities. This work involved participation in an international Coordinated Research Program on low-level waste disposal safety assessment (NSARS), conducting joint modeling exercises with 18 other countries. Dr. Kozak was a key member of this group, leading several of the activities.

In the area of residual contamination, Dr. Kozak was the principal technical evaluator of a proposed technical approach developed by NRC for the analysis of potential doses from contaminated soils and buildings. In the area of mixed waste, Dr. Kozak provided technical support to the U.S. Department of Energy (DOE) headquarters (department EM-331) to develop a technical rationale for defining minimally hazardous radioactive wastes and minimally radioactive hazardous wastes.

Dr. Kozak also conceived, initiated, and led a project to develop an electrokinetic method for removal of heavy metal contaminants from soils. While Dr. Kozak was at Sandia, the project developed a bench-scale experimental apparatus that provided the first demonstration of removal of contaminants by electrokinetics under unsaturated soil conditions. The project has since continued under another investigator at Sandia, and is currently moving to the field scale.

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Kessler, J., M.W. Kozak, M. Apted, W. Zhou, and G. Mungov, "EPRI's Total System Performance Assessment of Yucca Mountain using IMARC 9," Proc. International High-Level Waste Management Conference. Las Vegas, May 2006.

Smith, G., D. Jackson, M. Herben, and M.W. Kozak, "Biosphere Dose Conversion Factors for the Extrusive Igneous Release Scenario as Evaluated in the EPRI TPSA for Yucca Mountain," Proc. International High-Level Waste Management Conference. Las Vegas, May 2006.

Smith, G., D. Jackson, M. Herben, J, Merino, and M.W. Kozak, "Updated Biosphere Dose Conversion Factors for the Groundwater Release Scenario Taking Account of Climate Change and Natural Groundwater Discharge," Proc. International High-Level Waste Management Conference. Las Vegas, May 2006.

Morrissey, M.M, and M. W. Kozak, "Conceptual Models of Possible Igneous Consequences at Yucca Mountain Repository," Proc. International High-Level Waste Management Conference. Las Vegas, May 2006.

Park, J.W., C.L. Kim, J.B. Park, and M. W. Kozak, "Verification of a Safety Assessment Tool for Near-Surface LILW Disposal: System-Level Test with IAEA Vault Safety Case," Proc. Intl. Conf. on the Safety of Radioactive Waste Disposal, Tokyo, Oct 2005.

Kozak, M.W., M. Morrisey, F. King, M. J. Apted, and J. H. Kessler, "Consequences Of A Potential Igneous Disruption Of A High-Level Nuclear Waste Repository At Yucca Mountain, USA," Proc. Intl. Conf. on the Safety of Radioactive Waste Disposal, Tokyo, Oct 2005.

Kessler, J. H., M. W. Kozak, and Michael J. Apted, "Treatment Of Uncertainties Over Very Long Time Periods In Safety Assessment," Proc. Intl. Conf. on the Safety of Radioactive Waste Disposal, Tokyo, Oct 2005.

Stenhouse, M.J., M.W. Kozak, Y. Sekioka, M. Ishibashi, Y. Kawata, "Highlights of Review of L/ILW Disposal in European Countries, North America and Japan: Institutional Framework, Disposal Concepts, Assessment Approaches, Proc. Intl. Conf. on the Safety of Radioactive Waste Disposal, Tokyo, Oct 2005.

Kozak, M.W., M.J. Apted, and J.H. Kessler, "Consequences Of Potential Igneous Extrusive Releases From Yucca Mountain," WM'05 Conference, February 27 – March 5, 2005.

Kozak, M.W., J.W. Park and C.L. Kim, "Integration Of Safety Assessment And Data Management For A Low-Level Waste Disposal Facility In Korea," WM'05 Conference, February 27 – March 5, 2005.

Zhou, W., M.W. Kozak, J-W Park, C-L Kim, C-H Kang, "Development of SAGE Version 1.0, A Computer Code the Safety Assessment Analyses for Korean Low-Level Waste Disposal," Proceedings of the Annual Conference of the Korean Atomic Industrial Forum and the Korean Nuclear Society (KAIF/KNS), pp. 325-334, April 17-19, Seoul, 2002.

Park, J.W., C.L. Kim, J. B. Park, E. Y. Lee, Y. M. Lee, C. H. Kang, W. Zhou, and M.W. Kozak, An Integrated Safety Assessment System For Near-Surface Disposal Of Low- And Intermediate-Level Radioactive Waste In Korea, The 9th International Conference on Radioactive Waste Management and Environmental Remediation, Oxford, England September 21 – 25, 2003.

Foutes, C.E., K. Czyscinski, J. Bartlett, and M.W. Kozak "What is the Economic Impact of 40 CFR 197 on Yucca Mountain?," WM'02 Conference, February 24-28, 2002.

Kozak, M.W., "International Perspectives on Treatment of Uncertainty," invited plenary lecture at Environmental Stewardship: Promising Solutions to Uncertainty, New Orleans LA, February 5-7, 2002.

Kozak, M.W., C. Torres-Vidal, E. Kelly, A. Guskov, J. van Blerk, "Safety Cases For The Co-Ordinated Research Project On Improvement Of Safety Assessment Methodologies For Near Surface Radioactive Waste Disposal Facilities (ISAM)," IAEA-CN-90/70, Issues and Trends in Radioactive Waste Management, International Conference on Waste Management, Vienna, 9–13 December 2002.

Guskov, A., B. Batanjieva, M.W. Kozak, C. Torres-Vida1, "Radon-Type Disposal Facility Safety Case For The Co-Ordinated Research Project On Improvement Of Safety Assessment Methodologies For Near Surface Radioactive Waste Disposal Facilities (ISAM)," IAEA-CN-90/72, Issues and Trends in Radioactive Waste Management, International Conference on Waste Management, Vienna, 9–13 December 2002.

Van Blerk, J.J., V. Yucel, M.W. Kozak, and B.A. Moore, “Safety Assessment of a Borehole Type Disposal Facility Using The ISAM Methodology,” IAEA-CN-90/73, Issues and Trends in Radioactive Waste Management, International Conference on Waste Management, Vienna, 9–13 December 2002.

Kozak, M.W., J.J. van Blerk, and J.P. Vivier, “Borehole Disposal of Spent Radiation Sources,” Proc. International Symposium on Radiation Safety Management, November 5-7, Daejeon, Korea, pp 407-416, 2001.

Kozak, M.W., and A. Guskov, “Progress in Safety Assessment for Near-Surface Disposal Facilities in the Russian Federation,” International Symposium on Radiation Safety Management, November 5-7, Daejeon, Korea, pp 425-430, 2001.

Kozak, M.W., and L. Voronina, “Remediation of Mine Tailings from a Uranium Solution Mine at Krasnokamensk, Russian Federation,” Annual International Conference on Contaminated Soils, Sediments, and Water, University of Massachusetts, 2001.

Van Blerk, J.J., and M.W. Kozak, “Borehole Disposal of Spent Radiation Sources: 1. Principles,” IAEA-CN-78, pp. 194-187, Proc. International Conference of the Safety of Radioactive Waste Management, Cordoba, Spain, 13-17 March 2000.

Kozak, M.W., and J.J. van Blerk, “Borehole Disposal of Spent Radiation Sources: 2. Initial Safety Assessment,” IAEA-CN-78, pp. 48-51, Proc. International Conference of the Safety of Radioactive Waste Management, Cordoba, Spain, 13-17 March 2000.

Kozak, M.W., “Technical basis for environmental impact and safety assessments required for restoration and waste management projects,” invited plenary lecture to the Autumn Congress of the South African Radiation Protection Society, May 1999.

Kozak, M.W., “Safety Assessment of a Radioactive Waste Disposal Facility in the Former Soviet Union,” invited lecture to the Autumn Congress of the South African Radiation Protection Society, May 1999.

Ghassemi, A., Bonano, T., and M.W. Kozak, “Risk-based Decision Making.” PSAM Conference, 1998, New York.

Serebryakov, B. E., and M.W. Kozak, “Safety Assessment of the Radioactive Waste Disposal Facility, Which Belonged to Corporation “Radon,” in Proc. 4th International Symposium Ural Atomic, Ural Industrial, September 22-24 1998 (published in Russian as Оценка Безопасности пункта захоронения Радиоактивных Отходов, Принадлежавшево Объединению «РАДОН».)

Little, R H, M J Egan, M.W. Kozak, P R Maul and B M Watkins “Progress towards a Common Approach in Quantitative Assessment of Hazardous Waste Disposals,” Paper presented the Fourth International Symposium and Exhibition on Environmental Contamination in Central and Eastern Europe, Warsaw, September 15-17, 1998.

Kozak M.W., and B. E. Serebryakov, “Development of a Safety Assessment Methodology for Near-Surface Radioactive Waste Disposal Facilities in the Russian Federation,” invited presentation at the Institute of Nuclear Materials Management Conference, Cordoba, Spain, October 1997.

Kozak, M. W., “Sensitivity, Uncertainty, and Importance Analyses,” Proc. 18th Annual Department of Energy Low-Level Radioactive Waste Management Conference, 20-22 May, Salt Lake City, 1997.

Kozak, M.W., “Emerging Approaches to Environmental Risk Assessment,” Invited paper at the conference on The Role of Risk Assessment in Developing Reasonable Policy and Regulation, 15-18 April, Washington, DC, 1997.

Kozak, M. W., The Technical Basis for Residual Contamination Criteria for Decommissioned Nuclear Facilities in the United States, invited presentation at the Institute of Nuclear Materials Management conference, Troyes, France, April 1996.

Kozak, M. W., “Features of the Uncertainty in Safety Assessment of Radioactive Waste Disposal,” Proc. International Conference Spectrum 96, Seattle, August, 1996.

Kozak, M. W., “A Technical and Regulatory Foundation for Mixed-Waste Delisting,” Waste Management 96, Tucson, Arizona, 1996.

Kozak, M. W., "Validation, Confidence, and Performance Assessment," SPECTRUM 94, Proc. Nuclear and Haz. Waste Management Topical Meeting, pp 1354-1359, August 14-18, 1994.

Kozak, M. W., and T. A. Feeney, "The Sandia Environmental Decision Support System for Low-Level Waste Performance Assessment," Proc. 15th Annual DOE LLW conference, December 1993.

Kozak, M. W. "A Conceptual Approach to Low-Level Waste Performance Assessment," 1993 EPRI International LLW Management Conference, November 1993.

Lindgren, E. R., E. D. Mattson, and M. W. Kozak, Proc. DOE Workshop on Electrokinetic Remediation, Atlanta, Jan. 22-23, 1992.

Kozak, M. W., "Fundamentals of Electrokinetics," Proc. DOE Workshop on Electrokinetic Remediation, Atlanta, Jan. 22-23, 1992.

Lindgren, E. R., E. D. Mattson, and M. W. Kozak, "Electrokinetic Remediation of Contaminated Soils: an Update," Waste Management '92, pp. 1309-1314, 1992.

Rao, R. R., M. W. Kozak, J. T. McCord, and N. E. Olague, "Pathway Analysis for Alternate Low-Level Waste Disposal Methods,", Waste Management '92, pp. 1791-1798, 1992.

Rao, R. R., M. W. Kozak, and J. Rollstin, "Development of IMPACTS-BRC, Version 2.1," Waste Management '92, 1815-1820, 1992.

Kozak, M. W. "The NRC/SNL Performance Assessment Methodology For Low-Level Radioactive Waste Facilities", ASME publication, 1991 Joint International Waste Management Conference, Seoul, Korea, 1991.

Lindgren, E. R., M. W. Kozak, and E. D. Mattson, "Electrokinetic Remediation of Contaminated Soils," Environmental Remediation '91, p. 151, 1991.

Kozak, M. W., N. E. Olague, D. P. Gallegos, and R. R. Rao, "Treatment of Uncertainty in Low-Level Waste Performance Assessment", Proc. 13th Annual DOE LLW Conference, Atlanta, Nov. 19-21, 1991.

Kozak, M. W., and M. S. Y. Chu "Overview of a Performance Assessment Methodology for Low-Level Radioactive Waste Facilities", Waste Management '91, Tucson, Feb. 24-28, 1991.

Kozak, M. W. "A Comparison Between Simple and Detailed Methods for Analyzing Releases of Radionuclides to Ground Water From Low-Level Waste Facilities", Waste Management '91, Tucson, Feb. 24-28, 1991.

Deering, L. G., and M. W. Kozak "A Performance Assessment Methodology for Low-Level Radioactive Waste Facilities", Proc. 12th Annual DOE LLW Conference, Chicago, August 28-29, 1990.

ATTACHMENT 17

BRIAN GUTHERMAN

EDUCATION

- Rutgers University, New Jersey: B.S., Mechanical Engineering, 1982

PROFESSIONAL HISTORY

- CST Associates/ACI Nuclear Energy Solutions, Consultant, 2004-Present
- Holtec International, Licensing and Technical Services Manager, 1998-2004
- Florida Power Corporation, Crystal River Unit 3, QA Staff Engineer, 1986-1998
- Stone & Webster Engineering Corporation, Radiation Protection Group, 1982-1986

REPRESENTATIVE EXPERIENCE

- Twenty-six years of experience in the nuclear power industry.
- Assists nuclear power plant operators in performing spent fuel nuclear storage safely, legally, cost-effectively and in the lowest-dose manner possible.
- Consultant to the Nuclear Energy Institute and several nuclear utilities in the area of spent fuel storage, transportation and management.

REPRESENTATIVE PROJECTS

CST Associates/ACI Nuclear Energy Solutions
Currently serve as a consultant to the Nuclear Energy Institute and several nuclear utilities in the area of spent fuel storage, transportation, and management. For NEI, responsible for tracking all of the commercial spent fuel discharged by nuclear plants, where it is stored, what type of technology is used, and whether that technology is licensed for transportation aw well as storage. Assist the nuclear plant operators in performing spent nuclear fuel storage safely, legally, cost-effectively, and in the lowest-dose manner possible.

Holtec International
Worked as the Licensing and Technical Services Manager responsible for seeing in-process spent fuel storage and transportation cask certification applications through to successful issuance of NRC certificates of compliance. Responsible for several successful amendments to those CoCs. Represented Holtec on the NEI Dry Storage Task Force. Authored introductory, maintenance, and other support chapters of the cask SARs. Ensured the CoC proposed terms and conditions were consistent with the technical and analysis bases. Performed editorial review and integration of the SAR chapters from the technical disciplines (structural, thermal, shielding, criticality, confinement) and operations. Prepared all NRC submittals, including initial applications and responses to NRC requests for additional information, and facilitated Holtec's presentations at NRC meetings. Ensure the consistency of the various technical bases for the cask system design and authorized contents.

Florida Power Corporation (Crystal River Unit 3)
Held various titles over twelve years as an engineer and manager. As a mechanical design engineer, was responsible for major project engineering implementation. Supported effort for CR-3 to become the first plant in the country to adopt improved technical specifications. As Mechanical/Structural Design Engineering Supervisor, was responsible for supervision of a staff of engineers performing project engineering tasks. As Licensing Manager, was responsible for all licensing and compliance activities related to the operation of the plant. Was part of the first senior reactor operator certification class by successfully completing the full 5-month classroom training program and a one-month simulator course. As System Engineering supervisor was responsible for all secondary plant system operations, maintenance, and performance monitoring.

Stone & Webster Engineering Corporation
Member of the Radiation Protection Group. Performed design calculations in support of proposed structural and HVAC system designs and direct and airborne radiation dose estimates due to postulated accident events. Performed ALARA reviews of shielding and HVAC system designs. (Nine Mile Point, Unit 2 and River Bend Station pre-operational phase)

ATTACHMENT 18

RICHARD A. LOFTIN

EDUCATION

- University of Alabama, Birmingham, AL: Post Graduate Work, Mechanical Engineering
- Mississippi State University, Starkville, MS: B.S., Nuclear Engineering, 1974

PROFESSIONAL HISTORY

- Southern Nuclear Operating Co., Birmingham, AL, Senior Engineer, Nuclear Fuel Department, 1997-Present
- Georgia Power Co., Vogtle Plant, Augusta, GA, Senior Plant Engineer, Engineering Support, 1991-1997
- Georgia Power Co., Vogtle Plant, Augusta, GA, Senior Shift Technical Advisor, Operations, 1987-1990
- Georgia Power Co., Vogtle Plant, Augusta, GA, Plant Engineering Supervisor, Outage Planning and Scheduling Department, 1987-1987
- Georgia Power Co., Vogtle Plant, Augusta, GA, Plant Engineering Supervisor, Planning, Scheduling and Cost Department, 1984-1987
- Georgia Power Co., Vogtle Plant (under construction), Augusta, GA, Senior Plant Engineer, 1983-1984
- Southern Company Services, Vogtle Plant (under construction), Augusta, GA, Project Cost Engineer, 1980-1983
- Southern Company Services, Birmingham, AL, Project Mechanical Cost Engineer, 1979-1980
- Southern Company Services, Vogtle Plant (under construction), Augusta, GA, Field Mechanical Cost Engineer, 1978-1979
- Southern Company Services, Vogtle Plant (under construction), Birmingham, AL, Lead Cost Engineer, 1976-1978
- Southern Company Services, Birmingham, AL, Cost Engineer, 1974-1975
- Southern Company Services, Birmingham, AL, Assistant Cost Engineer, 1975-1976

AFFILIATIONS AND AWARDS

- Member of American Nuclear Society (Since 1972)
- Recipient of Westinghouse Customer Award in 2003

REPRESENTATIVE EXPERIENCE

- Over thirty years experience in nuclear power plant design, licensing, construction, engineering, and operation.
- Extensive experience in all aspects of engineering support for a nuclear power facility, including cost estimation, procedure implementation, reporting, mechanical cost reporting, and scheduling.
- Over two-decades of experience with new and spent nuclear fuel related issues, including long range refueling schedule planning, core offload, spent fuel pool shuffle, core reload and verification, control rod operability, and low power physics testing and Special Nuclear Materials custodian (Vogtle).
- Provide support to three nuclear plants sites, six units, for fuel inspections of new and spent nuclear fuel and dry cask loading.

REPRESENTATIVE PROJECTS

Southern Nuclear Operating Co
Mr. Loftin is responsible for providing support to three nuclear plants sites (a total of six reactor units), for fuel inspections of new and spent nuclear fuel and dry cask loading. He performs reviews of fuel performance issues for new designs, improvements and industry identified problems. He is also responsible for preparing and/or reviewing Significant Operating Event Report 96-02 evaluations and 10CFR50.59 (Plant Licensing Basis Changes) evaluations, and fuel integrity monitoring reports. In his role, Mr. Loftin is the prime contact and interface with industry vendors, other company personnel, and industry peers on all nuclear fuel related inspection issues and questions. Part of his responsibilities also include participating on industry committees regarding spent nuclear fuel dry storage issues related to storage casks and the proposed repository at Yucca Mountain.

Georgia Power Co. – Vogtle Plant
Over multiple years, Mr. Loftin held various engineering related positions of increasing responsibility at the Georgia Power Company's Vogtle Plant. His responsibilities included monitoring two reactor cores, including daily burn up and tech spec surveillances with equipment verification. He was the Custodian for Special Nuclear Materials (SNM), whose responsibilities included inventory maintenance and shuffle sheets for fuel movement. Mr. Loftin was also the System Engineer for refueling machine, fuel handling machine, refueling tools, spent fuel pool cooling, new fuel racks, spent fuel racks, and control rods. During his employment at Georgia Power, obtained his Senior Reactor Operator license. His responsibilities also included supervising the team responsible for development and implementation of refueling outage scheduling program and long range refueling schedule planning. He was also responsible for the supervision and implementation of a start-up cost/schedule program for the Vogtle Plant while under construction, which included scheduling and planning, scoping, cost engineering, and data operations.

Southern Company Services
Over multiple years, Mr. Loftin held various engineering related positions of increasing responsibility for Southern Company Services ("SCS"). He was responsible for the coordination and administration of a project cost control program. He prepared the project cost system for all mechanical cost data for R. W. Scherer Electric Generating Plant's four units. Mr. Loftin was responsible for new procedure implementation, existing procedure revision, and cost program compliance with guidelines for trending, forecasting, procurement cost control for SCS engineering department and SCS Vogtle Project.
He planned and conducted studies on floating nuclear plants, solvent refined coal-fired electric generating plants, and retrofit jobs for fossil electric generating plants.

ATTACHMENT 19

CHRISTOPHER FULLER, PH.D.

EDUCATION

- University of Washington, Seattle, WA: Ph.D., Geological Sciences, 2006
- University of Washington, Seattle, WA: M.Sc., Geological Sciences, 2002
- University of Washington, Seattle, WA: B.S., Geological Sciences, 2000, cum laude

PROFESSIONAL HISTORY

- William Lettis & Associates, Inc., Walnut Creek, CA, Project Geologist, 2007-Current
- William Lettis & Associates, Inc., Walnut Creek, CA, Senior Staff Geologist, 2006-2007
- UC Berkeley, Berkeley Seismological Lab, Berkeley, CA, Postdoctoral Researcher, 2006
- University of Washington, Department of Earth and Space Sciences, Seattle, WA, Teaching and Research Assistant, 2000-2006

AFFILIATIONS AND AWARDS

- National Science Foundation, Graduate Fellow, 2004-2006
- American Geophysical Union, Outstanding Paper & Presentation Award, fall national meeting 2000 and 2003
- University of Washington, David A Johnston Memorial Fellowship, 2004
- University of Washington, Peter Misch Fellowship, 2001-2003

REPRESENTATIVE EXPERIENCE

- Extensive experience in active tectonics and lithospheric geodynamics
- Dr. Fuller's professional work has focused on seismic hazard evaluations for critical facilities nationally and internationally, including geological characterization, seismic characterization and interaction with regulatory agencies.
- Dr. Fuller's research has advanced the understanding of the interaction between geologic structures and the seismic behavior of the crust. He has co-authored three grants to the National Science Foundation as part of this research.
- Dr. Fuller has directed research projects nationally and internationally that have included field mapping, sample collection, structural analysis, extensive data compilation across diverse disciplines, near-surface geophysical studies, and numerical modeling of crust deformation.

REPRESENTATIVE PROJECTS

South Texas Power Nuclear Operating Company COL Application, Matagorda County, Texas
Dr. Fuller performed ground and aerial reconnaissance fieldwork as well as literature review and analysis in support of South Texas Power's Units 3 & 4 nuclear power plant combined operating license. Dr. Fuller's work focused on developing regional and local seismic source models that were used in the seismic hazard assessment for the site and evaluating the potential for surface rupture beneath critical facilities at the site. Dr. Fuller's work has also included managing continued interaction with the NRC in addressing outstanding geologic and seismic hazard issues with the application as it proceeds through the regulatory process.

San Francisco Public Utilities Commission San Joaquin Pipeline No. 4, Stanislaus County, California
Dr. Fuller performed a probabilistic seismic hazard analysis for the public utilities commission that was used to develop the design basis for a proposed pipeline transporting water from the Sierra Nevada to San Francisco area. Dr. Fuller's work included the development of new fault characterizations and computing both probabilistic and deterministic ground motions.

Luminant Energy Comanche Peak COL Application, Somervell County, Texas
Dr. Fuller led a team developing the seismic and geologic source characterization used in the seismic hazard analysis for the Comanche Peak Units 3 & 4 nuclear power plant combined operating license. This work included fieldwork to evaluate potential seismogenic sources as well as literature review and data analysis focused on generating a local and regional seismic source models.

Calpine Geysers Geothermal Field Seismic Hazard Evaluation, Sonoma County, California
Dr. Fuller performed an analysis of the relationship between seismicity and hydraulic injection into the Geysers geothermal field to determine the potential seismic hazard in adjacent communities from activities within the geothermal field. Dr. Fuller's work primarily focused on the compilation and statistical analysis of seismicity and injection data.

Exelon Generation Company Victoria County Station COL Application, Victoria County, Texas
Dr. Fuller led a team developing the seismic and geologic hazard analysis for the Victoria County Station Units 1 & 2 nuclear power plant combined operating license. The geologic hazard evaluation focused on determining the potential for surface rupture from faulting using analysis of LiDAR, seismic reflection data, aerial reconnaissance, and ground reconnaissance. The seismic hazard analysis focused on the development of local and region source models used as input to the seismic hazard analysis for the site.

Nuclear Power Plant Siting Studies, Multiple Studies throughout US
Dr. Fuller has worked on several nuclear power plant siting studies throughout the US. Dr. Fuller's work on these studies has focused on developing siting criteria for geologic and seismic hazards at regional and local scales and applying these criteria to the selection of optimal sites. This work has included compilation and analysis of region and local geologic and seismologic data, development of seismic source characterizations, and computing probabilistic ground motions.

SELECTED PUBLICATIONS

Fuller, C.W., Willett, S.D., Fisher, D., 2006, A thermomechanical wedge model of Taiwan constrained by fission-track thermochronometry: Tectonophysics, v. 425, p. 1-25.

Fuller, C.W., Willett, S.D., Brandon, M.T., 2006, Formation of forearc basins and their influence on subduction zone earthquakes: Geology, v. 34, p. 65-68.

Ehlers, T.A., Chaudhri, T., Kumar, S., Fuller, C.W., et al., 2005, Computational Tools for Low-Temperature Thermochronometer Interpretation, *in* T.A. Ehlers and P.W. Reiner, eds., Low-Temperature Thermochronology: Techniques, Interpretations and Applications: Mineralogical Society of America, Chantilly, p. 590-622.

Willett, S.D., Fisher, Fuller, C.W., Yeh, E-C, Lu, C-Y., 2003. Erosion rates and orogenic wedge kinematics in Taiwan inferred from fission-track thermochronometry: Geology, v. 31, p. 945-948.

Fuller, C.W., Willett, S.D., Slingerland, R. and Hovius, N., 2003, A Stochastic Model of Sediment Supply, Transport and Storage in a Taiwan Mountain Drainage Basin: Journal of Geology, v. 111, p. 71-87.

ATTACHMENT 20

MICHAEL G. GRAY, M.S., C.E.G.

EDUCATION

- California State University, Long Beach: M.S., Geological Sciences, 2000
- California State University, Humboldt: B.S., Geology, 1985

REGISTRATIONS

- Professional Geologist: California (1995), and Washington (2002)
- Certified Engineering Geologist: California (1996), Washington (2002)

PROFESSIONAL HISTORY

- William Lettis & Associates, Inc., Walnut Creek, CA, Principal Engineering Geologist, 2005-Present
- Camp Dresser & McKee, Inc., Carlsbad, Irvine, and Walnut Creek, CA, Principal Geologist, 1991-2005
- Nolte Associates, Inc. (formerly Mission Viejo Company), Mission Viejo, CA, Project Geologist, 1990-1991
- Mission Viejo Development Company, Mission Viejo, CA, Project Geologist, 1985-1990

AFFILIATIONS AND AWARDS

- Association of Engineering Geology
- Geologic Society of America

REPRESENTATIVE EXPERIENCE

- Over 20 years of experience designing, conducting, and managing complex geologic, geotechnical, and hydrogeologic studies on a wide variety of projects including energy facilities, water supply and water resource, reservoirs and dams, pipelines, canals, large-scale land development, and transportation projects for municipal and private entities.
- Expertise is focused on data acquisition, characterization and interpretation of complex geologic and hydrogeologic conditions, and geologic hazard assessments and mitigation evaluations.
- Substantial practical expertise in conducting landslide inventory analysis, slope stability evaluations, and mitigation designs including exposure risk and safe setback assessments in landslide prone regions.

REPRESENTATIVE PROJECTS

Principal Geologist, Combined Construction and Operating License (COL) Application William States Lee III, Nuclear Power Facility, South Carolina, Duke Energy

Responsible for direct management of Duke Energy’s proposed William States Lee III Nuclear Station COL project.. Responsible for the geology, geotechnical and seismic studies for the Final Safety Analysis Report. Manages all technical aspects associated with program development, data acquisition, analysis and interpretation, and report preparation including supporting calculation packages and project reports. Developed the Data Collection Plan, QA/QC technical procedures and work instructions used to guide field and laboratory testing activities. Results and data from this investigation will be used to (1) characterize site geologic conditions and potential hazards, (2) develop a geotechnical profile (Geotechnical Model) to evaluate site earthquake response and foundation properties and stability, and (3) to develop foundation and site development geotechnical criteria. All data and analysis is subject to a formal QA/QC review, and will be summarized in the Final Safety Analysis Report for NRC review and acceptance.

Principal Engineering Geologist, Peer Review for Multiple Combined Operating and Licensing Applications, Various South Eastern United States Sites
Performed independent technical review for project reports and calculations packages related to important site characterization evaluations including development of geologic profiles, selection of static and dynamic material properties, and ground motion evaluations.

Principal Engineering Geologist, Fatal Flaw Siting Evaluations for Proposed New Nuclear Power Facilities, Texas
Led reconnaissance-level evaluations at multiple sites; relied on initial siting criteria used to assess geologic, seismologic, and geotechnical engineering properties. The results of these evaluations were compared to multiple vendor technologies allowing site rankings by site/technology to be developed.

Engineering Geologist, Marysville Road, Reconnaissance Mapping and Preliminary Design, Montana Department of Transportation
Responsible for the geologic characterization and related design elements for the 8-mile long Marysville Road alignment. The field program focused on mapping the distribution rock units, identification and classification of primary and secondary structures such as orientation and characterization of rock discontinuities including seepage and mineral alteration, degree of weathering, and evaluating areas of existing and potential slope instability. The results were detailed in a preliminary design report presenting a geologic strip map of the alignment, cross sections at identified critical slopes, rock mass properties with kinematic rock slope stability analysis, preliminary design recommendations for permanent rock cut slopes and delineation of abandoned mine structures, and supplemental studies.

Geotechnical Project Manager/Engineering Geologist, Geotechnical Investigation for Replacement of Terminal Reservoir No. 3, City of San Juan Capistrano
Evaluated bedrock strength properties, defining the geologic structure with specific focus on characterizing the geometry of existing landslides and evaluating failure modes and overall slope stability throughout the canyon setting. Additional responsibilities include designing and installing an instrumentation system, consisting of a series of slope inclinometers and nested piezometers, to evaluate potential deformation and groundwater conditions of an existing fill and natural slope. Project design challenges include demolition of an existing 2-MG reservoir while protecting an adjacent operational 10-MG reservoir, evaluating landslide hazard mitigation options including static/pseudo static slope stability analysis, and design of temporary/permanent slope and tieback wall configurations within the landslide prone Late Miocene Capistrano Formation.

Project Geologist, San Joaquin Hills Transportation Corridor, Newport Coast/Irvine, CA, Mission Viejo Development Company and Nolte and Associates, Inc.
Responsible for the geotechnical investigation for the preliminary design of Section S-09 toll way. This 2.2-mile long toll way segment included field investigation, geologic characterization, and developing design recommendations for 6 bridge structures and a cut and cover tunnel. This investigation included detailed stability evaluations for over twenty cut and fill slopes up to 105 feet high. Conducted aerial photograph review and interpretation, reconnaissance and detailed geologic mapping, geophysical surveys, sampling and logging of disturbed and undisturbed surficial and bedrock materials utilizing a variety of drilling and excavation methods, sampling and logging 37-bucket auger and hollow stem auger boreholes, ten test pits, mapping, and installation of piezometers.

Project Geologist, Various Projects, Mission Viejo Development Corporation
Project geologist for numerous large residential and commercial developments.. Developed and performed geotechnical investigations including landslide and fault evaluations, land plan and grading

plan reviews, developing design recommendations including landslide and slope stability exposure risk and safe setback evaluations, construction inspection, and as-built reporting.

Project Director/Engineering Geologist, City of Los Angeles Department of Public Works, Geotechnical Engineering Division, NEIS Tunnel Geotechnical Investigation
Project Director/Engineering Geologist for the City of Los Angeles' Northeast Interceptor Sewer (NEIS) Tunnel Investigation, responsible for directing all elements of this fast-tracked, complex geotechnical investigation. Nearly 1,500 meters of soil/rock were drilled, logged, and sampled for three deep shafts and the 9-kilometer tunnel alignment. Responsibilities included planning all exploration activities and supervising geologic staff, reviewing geologic material samples, rock sample test selection, interpretation of geologic and geophysical data, training of project and city personnel, and quality assurance/control elements. One major challenge managed during this project required the collection of high quality cores within highly variable geologic formations. Collaborating with City geologists and the tool manufacturer, he assisted in developing a customized HQ drill bit that increased core recovery up to 90% from an average of 50%, resulting in enhanced rock mass characterization and improved site characterization.

Lead Engineering Geologist, Yolo Force Main (LNWI), Sacramento Regional County Sanitation District
Responsibilities included section preparations and overall QA/QC review responsibilities for the geotechnical evaluations to support pre-design and final design phases of this project, including the preparation of GDR, GIR, GBR. Functioned as the senior engineering geologist to develop owner responses to contractor RFIs, review and acceptance of contractor submittals.

Project Geologist, Napa-Sonoma Marsh Restoration Project EIS/EIR, Sonoma County Water Authority
The purpose of the EIS/EIR was to evaluate multiple pipeline alignments and characterize geologic hazards to support project evaluations to support the EIR for the restoration of approximately 700 acres of salt pond area to wetlands habitat using tertiary treated wastewater contributed from 6 regional wastewater treatment plants. Mr. Gray was responsible for the evaluation of the geotechnical constraints for development of the EIR/EIS alignment studies for over 10 miles of pipeline.

Program/Project Manager, Bay Area Rapid Transit District (BART)
Project manager for the BART's general environmental services contract with a total value of over $5 million. Responsibilities included executing all project elements: from project scoping and planning during initial project development, staff assignments, preparing cost proposals and schedules, supervising multiple tasks using a variety of specialty subcontractors, quality and cost control. Instrumental in developing a soil reuse plan and subsequent first-time review/approval by the Regional Water Quality Control Board.

Program/Project Manager, Port of Oakland
Responsibilities included performing and managing project staff in support of the Port's 2000 Construction Program that included developing new marine terminals and upland rail yard and container facilities. Responsibilities for this $600,000 three year multi-service order contract included managing the operation, maintenance, and monitoring at two on-site groundwater treatment systems; and assisting the Port in conducting ecological and human health risk modeling, including model development and evaluations to support final design concepts. A substantial part of his efforts led to developing acceptable soil and groundwater threshold levels protective of ecological and human health for the Port's Berths 55-59 project. The soil and groundwater threshold levels were incorporated into the Port's waste discharge requirements adopted by the San Francisco Regional Water Quality Control Board.

Project Geologist, HDR, Seismic Retrofit Fletcher Drive Bridge, Los Angeles, CA
Responsible for all aspects of the collection and interpretation of subsurface geotechnical data. Data evaluation included interpreting geologic and seismic hazard maps, boring logs, and seismic refraction profile data. This information formed the basis of the subsurface characterization, liquefaction analysis, and structural design for the seismic retrofit of this historic bridge spanning the Los Angeles River.

Project Geologist, Landfill Groundwater Investigations
Responsibilities included collecting soil samples, lithologic logging, characterizing subsurface conditions, installing and developing groundwater monitoring wells, and preparing all reports. These investigations were designed to define the complex hydrogeologic conditions beneath the landfills and to assess whether the waste management unit impacted groundwater in accordance to California Code of Regulations, Title 23, Chapter 15, Article 5.

Project Geologist, County of Orange
As project geologist for design and construction of a landfill leachate extraction system at the Santiago Canyon Landfill for County of Orange Integrated Waste Management Department, responsibilities included the analysis of subsurface hydrogeologic conditions, extraction well design, preparation of contract bid and specification documents, review of contractor submittals, and construction management.

SELECTED PUBLICATIONS

Oborne, M., F. Burnett, C. Johnson, and M. Gray, Geotechnical Investigation for the Northwest Interceptor Sewer, City of Los Angeles, CA, Association of Engineering Geologists, 2002 Annual Meeting.

Shifflett, H., M. Gray, R. Grannell, and B.L. Ingram, New Evidence on the Slip Rate, Renewal Time, and Late Holocene Surface Displacement, Southernmost San Andreas Fault, Mecca Hills, CA, Bulletin of Seismological Society of America, October 2002.

Gray, M.G., and H. Shifflett, Evidence for a Newly Discovered Active Fault of the San Andreas Fault System, Mecca Hills, CA, American Geophysical Union 1996 Annual Meeting.

ATTACHMENT 21

DANIEL R.H. O'CONNELL, Ph.D.

EDUCATION

- University of California, Berkeley, CA: Ph.D.,Geophysics, 1986
- University of California, Berkeley, CA: M.S., Geophysics, 1982
- Purdue University, West Lafayette, IN: B.S., Geophysics, 1980

PROFESSIONAL HISTORY

- William Lettis & Associates, Inc., Walnut Creek, California, Senior Geophysicist, 2007-Present
- Bureau of Reclamation, Denver, Colorado, Geophysicist and Supervisory Geophysicist, Seismotectonics and Geophysics Group, 1991–2007
- The Ohio State University, Columbus, OH, Post-Doctoral Researcher and Research Scientist, 1986-1991
- Graduate Research Assistant, University of California, Berkeley, CA, 1982-1986
- U.S. Geological Survey, Menlo Park, CA, Physical Science Technician 1978-1982
- Bendix, United Geophysical, Utah, Seismic Reflection Crew, 1977

AFFILIATIONS AND AWARDS

- Life Member, Seismological Society of America
- Life Member, American Geophysical Union

REPRESENTATIVE EXPERIENCE

- Thirty years experience in geophysical investigations of earthquake and flood hazards.
- Provided technical services and project management on numerous studies related to water projects nationally and internationally, including probabilistic and deterministic seismic hazard investigations, geophysical site characteristics for earthquake engineering, site-specific ground motion modeling, and hydrodynamic and flood-frequency investigations for flood hazard and dambreak studies.
- Played a lead technical role at the Bureau of Reclamation; developed standards and procedures for the conduct of probabilistic seismic and flood hazard studies of critical infrastructure, conducting seismotectonic, ground motion, and flood studies throughout the United States.
- Instrumental in pioneering techniques to improve 2D hydraulic modeling of steady-state and dambreak flows and incorporating paleoflood information in Bayesion flood frequency o develop probabilistic estimates of flood hazard. Studies funded by the Department of Energy expanded the scope and process to a comprehensive probabilistic and GIS-based product.
- Served as principal investigator on thirteen research projects sponsored by the U.S. Bureau of Reclamation, the National Science Foundation and NASA.
- Provides technical advice and peer review foe seismic and flood hazard investigations throughout the United States and abroad.

REPRESENTATIVE PROJECTS

Flood Hazard Evaluations, Idaho National Laboratory, Idaho, U.S. Department of Energy
Develop probabilistic models of flood hazard for the Big Lost River on the Idaho National Laboratory. Flood hazard data are used by DOE to meet regulatory needs ranging from FEMA-type flood plain studies to low-probability evaluations for nuclear facilities. Studies were conducted to evaluate Holocene paleoflood history of the Big Lost River and developed a detailed paleoflood history of the river system from geomorphology, trenching, soils, sedimentology, two-dimensional flow simulations, and digital

topographic data. Developed a two-stage approach to high-resolution 2D inundation modeling using finite-difference and finite-element methods, including an optimized-resolution spatially-varying finite-element mesh to produce accurate inundations for large ranges of peak discharge efficiently with a single computational mesh. Produced nonparametric Bayesian flood-frequency and probabilistic stage estimates. Final products included probabilistic evaluations of peak discharge flood frequency and stage for selected facility sites, detailed documentation of geologic trenching and Quaternary geologic studies, detailed topographic data used for geomorphic analyses and flood modeling inputs, and GIS data of flood modeling results depicting inundation, depth, stream power, and shear stress. The project included extensive external peer review and quality assurance requirements.

Probabilistic Ground Motions for East Canyon and Echo Dams, Utah
Performed velocity-hypocenter inversions to estimate 3D structure to locate earthquakes and develop seismotectonic models of earthquake fault geometries. Acquired and interpreted seismic reflection data to further constrain local fault geometries and crustal velocity structure. Implemented a detailed 3D crustal velocity model and performed 3D dynamic fault rupture modeling of scenario normal-faulting earthquakes on the East Canyon fault to estimate near-fault ground motions for both dams. Developed-UHS-spectra-compatible probabilistic ground motion time histories for dynamic analyses of the dams. Modified scenario ground motion time histories to provide direct subsurface inputs into LSDYNA and FLAC engineering models used to evaluate the dams' performance during seismic loads.

Probabilistic Ground Motions for Hungry Horse Dam, Montana
Performed velocity-hypocenter inversions to estimate 3D structure to locate earthquakes and develop seismotectonic models of earthquake fault geometries. Installed a four-station temporary broadband digital seismographic network to record and locate local earthquakes and use the temporary network data to estimate seismic velocities of the foundation and upper crust using the dam as a passive seismic source. Used passive seismic monitoring within the dam to determine the frequencies and damping of the dam's resonant modes of oscillation to assist structural engineering calibrations of 3D finite-element models of the dam and the foundation. Performed 3D dynamic fault rupture modeling of scenario normal-faulting earthquakes on the South Fork fault to estimate near-fault ground motions for the dam. Used empirical Green's function (EGF) ground motion modeling to provide site-specific probabilistic ground motions appropriate for high-velocity-foundation site conditions for very small annual exceedence probabilities. Modified scenario ground motion time histories to provide direct inputs into the LSDYNA engineering models used to evaluate the dams' performance during seismic loads.

Performance Assessment and Improvement of Hydrodynamic Mathematical Models via Field Observations and Controlled Laboratory Experiments (U.S. Bureau of Reclamation Science and Technology Research Program)
Working with Roger Denlinger of the USGS, developed a new nonhydrostatic 2D finite-volume method to calculate dambreak and steady-state flows and tested the ability of the method to predict stages, velocities, and shear stresses throughout the transcritical flow regime using clear water and sediment flumes. Worked with Roy Walters of Ocean River Modeling to demonstrate that his RICOM 2D and 3D semi-implicit- semi-Lagrangian code, that includes the capability to model cohesive/non-cohesive sediment transport, accurately predicts flow stages and velocities in transcritical flow regimes (http://www.niwascience.co.nz/pubs/wa/10-4/sediments). This project also collaborated with a project to use hydrophones to monitor sediment transport and we are currently evaluating the ability of broadband seismographs to monitor sediment transport.

2.5D Modeling of Catastrophic Floods in Athabasca Valles, Mars, NASA Research
Used our new nonhydrostatic 2D flow modeling code to investigate channel morphology and identify region of scour and deposition associated with extreme outburst floods in Athabasca Valles, Mars. Channel reaches mapped as erosional or depositional are being compared to model output of the 3d distribution of 'stream power' (the product of bed shear stress and velocity) dissipated on the bed.

Multiple discharge scenarios are being run with multiple grid scenarios to assess the importance of Martian topographic uncertainties on estimates of stage, velocity, erosion, and deposition.

Seismotectonic and Ground Motion Characterization, Sierran Foothills, Folsom Dam, California
Performed velocity-hypocenter inversions to estimate 3D structure to locate earthquakes and develop seismotectonic models of earthquake fault geometries. Used 3D finite-difference modeling to estimate focal mechanisms and to calculate ground motions for local normal-faulting scenario earthquakes. Developed hard rock EGF ground motions to develop broadband probabilistic ground motions for dynamic analyses of the dam.

2D Inundation Modeling of Proposed Potholes Water Diversion (U.S. Bureau of Reclamation)
Used high-resolution topography to model a wide range of discharge scenarios to determine channel capacities and potential impacts of water diversions through a ~20 mile reach of Crab Creek in eastern Washington. Provide stages, velocities, bed shear stresses, and stream power on 2D GIS outputs using 4-20 ft postings. Field flow tests demonstrated that the 2D flow calculation method accurately predicted the discharges required to produce out-of-bank flows and inundations of low-elevation cultivated fields where 1D flow calculations fail to accurately predict stages and associated out-of-bank inundation.

2D Inundation Modeling for Three Hattian Landslide Dam Breach Scenarios
On October 8, 2005, a M 7.6 earthquake near Muzafarrabad, Pakistan, triggered a landslide that dammed the Karli River and one of its tributaries about 4 km upstream of the confluence of the Karli and Jhelum rivers near the town of Hattian Bala. The largest dammed lake on the Karli River will impound about 60 million cubic meters of water. This lake will drain through the landslide dam as it breaches during the spring runoff or during the monsoon season in early summer. The inundation associated with the Karli River landslide dam breach endangers a substantial downstream population, particularly the population located in the vicinity of Hattian Bala at the confluence of the Karli and Jhelum rivers. To help mitigate this hazard, I worked with Dr. Roger Denlinger of the USGS to use a new non-hydrostatic accurate two-dimensional flow model to simulate dambreak flows associated with three breach-rate downcutting scenarios, and estimated inundation depths and peak flow velocities. We superimposed inundation extents and other attributes on photographic images of the region to provide clear delineation of potential impacts on populated areas near the confluence of the Karli and Jhelum rivers.

Probabilistic Seismic Hazard, Ground Motion, and Seiche Wave Analyses for Joes Valley Dam
Working with Dr. Roy Walters of Ocean/River Modeling we developed probabilistic seiche stages for scenario faulting involving four faults intersecting the reservoir and producing 4m of fault displacement within portions of the reservoir. We developed full dynamic 3D surface displacement fields using 3D viscoelastic finite-difference calculations of with kinematic finite-fault rupture models to evaluate the influence of earthquake fault rupture rates on estimated seiche stages. Used local earthquakes recorded at the dam to develop the foundation site responses for ground motion modeling. Performed kinematic and dynamic fault rupture modeling of scenario normal-faulting earthquakes on the Joes Valley faults to develop probabilities site-specific ground motions for the dam.

Hydraulic Modeling Tools for Paleoflood Analyses (U.S. Bureau of Reclamation Dam Safety Research Program)
Working with Dr. Roy Walters of Ocean/River Modeling we developed robust and accurate modeling tools to convert paleostage observations into discharge estimates to be used in flood-frequency analyses for Reclamation dams. The ability of the model to predict scour and deposition even in extreme transcritical flow regimes was demonstrated through geomorphic field investigations of the Verde River after the large floods of 1993. Working with Kyle House and Roger Denlinger, we showed that 2D flow estimates of bed shear stress and stream power accurately predicted regions of scour and deposition observed along the Verde River above and below a sharp bend and bedrock constriction that produced a

large transcritical flow transition. We showed that discharge and bed roughness are uniquely constrained using profiles of maximum inundation along the channel margins extending upstream and downstream from the transcritical flow constriction and that 2D flow modeling is required to explain stage and scour and deposition variations throughout the study reach.

Paleoflood Evaluations, Folsom Dam, California
Calculated steady-state 2D flow fields for wide ranges of discharges in multiple reaches in several western Sierra Nevada Rivers, including American, Cosumnes, and Stanislaus. Calculated 2D estimates of power to derive bounds of paleoflood peak discharges and incorporated the information and developed a new nonparametric Bayesian-flood frequency estimation method to incorporate full paleoflood measurement uncertainties in probabilistic estimates of flood hazards.

SELECTED PUBLICATIONS

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Denlinger, R.P., and D. R. H. O'Connell (2007), Computing nonhydrostatic shallow water flow over steep terrain, submitted to the ASCE Journal of Hydraulic.

O'Connell, D.R.H., S. Ma, and R.J. Archuleta, 2007, Influence of dip and velocity heterogeneity on reverse- and normal-faulting rupture dynamics and near-fault ground motions, , *Bull. Seis. Soc. Am.*, in press.

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Ostenaa, D.A., O'Connell, D.R.H. Walters, R.A., and Creed, R.J., 2002, Holocene paleoflood hydrology of the Big Lost River, western Idaho National Engineering and Environmental Laboratory, Idaho, in Link, P.K., and Mink, L.L., eds., Geology, Hydrogeology, and Environmental Remediation, Idaho National Engineering and Environmental Laboratory, Eastern Snake River Plain, Idaho: Boulder, CO, Geol. Soc. Amer. Special Paper 353, p. 91-110.

O'Connell, D.R.H., Unruh, J.R., and Block, L.V., 2001. Source characterization and ground-motion modeling of the 1892 Vacaville-Winters earthquake sequence, California, *Bull. Seis. Soc. Am.*, 91, 1471-1497.

O'Connell, D.R.H., 1999. Replication of apparent nonlinear seismic response with linear wave propagation models, *Science*, 283, 2045-2050.

O'Connell, D.R.H., Levish, D.R., and Ostenaa, D.A., 1998, Risk-based hydrology: Bayesian flood-frequency analyses using paleoflood information and data uncertainties in Proceedings of the First Federal Interagency Hydrologic Modeling Conference: Las Vegas, Nevada, v. 1, p. 4.101 - 4.108.

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Levish, D.R., Ostenaa, D.A., and O'Connell, D.R.H., 1997, Paleoflood hydrology and dam safety: Waterpower '97, in Proceedings of the International Conference on Hydropower: Atlanta, Georgia, p. 2205-2214.

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O'Connell, D.R.H., Levish, D.R., and Ostenaa, D.A., 1996, Bayesian flood frequency analysis with paleohydrologic bounds for late Holocene paleofloods, Santa Ynez River, California, in Gruntfest, E., ed., Twenty years later what we have learned since the Big Thompson flood: Boulder, Colorado, University of Colorado, Natural Hazards Research and Applications Information Center, Special Publication No. 33, p. 183-196.

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Ostenaa, D.A., Levish, D.R., Klinger, R.E., and O'Connell, D.R.H., 1999, Phase 2 Paleohydrologic and geomorphic studies for the assessment of flood risk for the Idaho National Engineering and Environmental Laboratory, Idaho: Geophysics, Paleohydrology, and Seismotectonics Group, Bureau of Reclamation, Denver, CO, Report 99-7, 112 p., 1 folded plate, 4 appendices.

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Anderson, L.W., and D.R. O'Connell, 1993, Seismotectonic study of the northern portion of the Lower Colorado River, Arizona, California, and Nevada, U.S. Bureau of Reclamation Seismotectonic Report 93-4, 122 pp.

ATTACHMENT 22

MICHAEL J. APTED, Ph.D.

EDUCATION

- Stanford University, School of Earth Sciences, Post-Doctoral Studies, May 1980- July 1982
- University of California, Los Angeles, CA: Ph.D., Geochemistry, 1980
- Massachusetts Institute of Technology: B.S., Chemistry 1974

PROFESSIONAL HISTORY

- Monitor Scientific, LLC, Denver, CO, President, 1996-Present
- QuantiSci Inc. (formerly Intera Information Technologies, Inc.), Denver, CO, Managing Director of US Operations, 1990-1999
- Pacific Northwest Laboratories, Richland, Senior Staff Scientist, 1985-1990
- Rockwell Hanford Co., Richland, WA, Senior Scientist, 1982-1985
- U.S. Department of Energy, Waste/Barrier/Rock Interactions Testing Program, Project Manager, 1982-1985
- U.S. Department of Energy, Waste Package Activities of the Performance Assessment Scientific Support (PASS) Program, Manager, 1987-1990
- Japanese Power Reactor and Nuclear Fuel Development Corporation, Performance Assessment Center for Engineered Barriers (PACE) Program, Technical Manager, 1987-1990

AFFILIATIONS AND AWARDS

- International Technical Advisory Committee (ITAC) to the Nuclear Waste Management Organization of Japan (NUMO)
- US National Academy of Sciences/ National Research Council committee reviewing pyrochemical processing and development of associated waste forms.

REPRESENTATIVE EXPERIENCE

- Over twenty-five years of experience in research and development related to nuclear waste disposal, primarily in the areas of materials testing under simulated subsurface conditions and safety/risk analysis of geological disposal of hazardous and radioactive wastes.
- Fifteen years in technical management of safety/risk analysis of engineered barrier structures for the isolation of radioactive wastes for programs with the U.S. Department of Energy, as well as international repository projects and regulatory agencies.
- Fifteen years in operational management of a environmental consulting company with worldwide business in the U.S., Canada, Europe and Asia.
- Twenty-five years research experience in applied chemical and advanced spectrometric analysis of earth materials, including solids, water, and gases.
- Eighteen years as a consultant to national and international nuclear waste agencies, including the National Academy of Sciences, the International Atomic Energy Agency and the Nuclear Energy Agency.

REPRESENTATIVE PROJECTS

Monitor Scientific, LLC

As President of Monitor Scientific, Dr. Apted works as a technical consultant to industries and governments in the field of nuclear waste management. He has consulted for the French, Swedish, Canadian, Spanish, German, Finnish, Swiss South Korean, Taiwanese and South African repository programs investigating nuclear-waste disposal, as well as being a consultant to the International Atomic Energy Agency on disposal of spent fuel and sealed radiological sources. Currently he is an technical advisor to the regulatory agencies for nuclear waste disposal in Sweden (SKI) and Finland (STUK), respectively.

U.S. Department of Energy

As Project Manager of the U.S. Department of Energy's Waste/Barrier/Rock Interactions Testing Program, Dr. Apted developed a testing and analysis program for assessing long-term performance of nuclear waste forms. As Manager for the Waste Package activities of the Performance Assessment Scientific Support (PASS) Program, Dr. Apted co-developed the AREST code for evaluating the safety of the engineered barriers of a high-level waste repository system.

Electric Power Research Institute

Dr. Apted was a principle author of the Electric Power Research Institute's risk assessment model for HLW disposal in a geological repository at Yucca Mountain, Nevada, USA. His particular research expertise is on performance of engineered barrier systems and integration of near-field geochemistry with degradation of engineered materials. He also been involved in independent review of postulated failure scenarios for repository systems.

Japanese Power Reactor and Nuclear Fuel Development Corporation

Dr. Apted was a principal editor of the English version of the H12 Second Progress Report for HLW disposal, published by Japanese Power Reactor and Nuclear Fuel Development Corporation (JNC) in 2000. He was the Technical Manager of JNC's Performance Assessment Center for Engineered Barriers (PACE) Program for studies of actinide chemistry, innovative waste package design, and computer simulation of thermal-chemical-hydrological-mechanical conditions in a nuclear waste repository. Dr. Apted is a member of the, and also serves as a coordinator of NUMO's International Tectonics Meetings investigating faulting, seismic and volcanism hazards analyses.

SELECTED PUBLICATIONS

Apted, M. 1984. "Laboratory and field data needs for site-specific repository modeling", Material Research Society Sypos. Proceed., Vol 26, 77-84, North Holland, New York, NY.

Langmuir, D. and M. Apted. 1992. "Backfill modification using geochemical principles to optimize high-level nuclear waste isolation in a geological repository, Material Research Society Sypos. Proceed., Vol 257, 13-24, Materials Research Society, Pittsburgh PA.

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Apted, M. 1995. "Repository and barrier concepts', in The Scientific and Regulatory Basis for the Geological Disposal of Radioactive Waste, John Wiley & Sons, Chichester, UK.

Apted, Michael J. and R.Westerman (eds), 1995, The Scientific and Regulatory Basis for the Geological Disposal of Radioactive Wastes. John Wiley & Sons.

Apted, M. (Committee Member). 2000. Final Report: for Electrometallurgical Techniques for DOE Spent Fuel Treatment, Board on Chemical Sciences and Technology, National Research Council, Washington DC.

Apted, M. and D. Langmuir. 2005. Review of Alternative Models and Supporting Evidence for Maximum Neptunium Concentrations at the Proposed Yucca Mountain Repository, Technical Report No.1012104, Electric Power Research Institute, Palo Alto,

Chang, F.-L. Zhou, W. Shih, C.-F.; Apted, M. Chen, C.-L.; and Li, J.-C. 2006 "Post-closure safety assessment of horizontal KBS-3-type repository," Proceedings of the International High-Level Radioactive Waste Management Conference, 11th, Las Vegas, NV, 1017-1023, American Nuclear Society, La Grange Park, IL.

Apted, M. (Program Manager). 2007. Program on technology Innovation: EPRI Yucca Mountain Spent Fuel Repository Evaluation, 2007 Progress Report, Technical Report No.1015045, Electric Power Research Institute, Palo Alto,

ATTACHMENT 23

MEGHAN M. MORRISEY, Ph. D.

EDUCATION

- Arizona State University, Ph.D., Geology, 1994
  Dissertation: "Magmatic fluids and long-period seismicity: a geological and fluid dynamical perspective"
- University of Texas at Arlington, M.S., Geology, 1990
  Thesis: "Application of results from Fe-Al melt-water explosion experiments to hydrovolcanic eruptions"
- Michigan Technological University, B.S., Geological Engineering, 1987

PROFESSIONAL HISTORY

- Consultant to Monitor Scientific Ltd. on Yucca Mtn Project., 2003 to present
- Consultant to Nuclear Waste Technical Review Board, 2001 – 2003
- Associate Research Professor, Colorado School of Mines, 1997 to present
- Contract Employee with the U.S. Geological Survey, 1997-2000
- National Science Foundation Postdoctoral Fellow at the U.S.G.S in Menlo Park, 1994-1996
- Research Assistant at Arizona State University, 1991-1994
- Staff Research Assistant at Los Alamos National Laboratory, NM, 1989-1990
- Field Geologist for Copar Pumice Company, Espanola, NM, 1989-1990
- Civil Engineer Technician, Nowak and Frauss, Royal Oak, MI, 1987-1988
- Civil Engineer Technician, U.S. Dept. of Transportation, Boone, N.C., 1986-1987

REPRESENTATIVE EXPERIENCE

- Dr. Morrissey has experience with basaltic systems in locations such as Iceland (i.e. Lakagigar, Krafla), Japan (Sakurajima), Mexico (Pinacates), and the U.S. (i.e. Hawaii, Hopi Buttes, and San Francisco and Crater Flat volcanic fields).

PUBLICATIONS

Morrissey, M. M., Wieczorek, G. F., Morgan, B.A. (2007). A Comparative Analysis of Simulated and Observed Landslide Locations Triggered by Hurricane Camille in Nelson County, Virginia. Hydrological Processes Journal, John Wiley and Sons

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Morrissey, M.M., G.F. Wieczorek, and B.A. Morgan (2001). A comparative analysis of hazard models for predicting debris flows in Madison County, Virginia. U.S. Geol. Surv. Open File Rep. 01-67. pp. 01-67.

Morrissey, M.M., B.A. Chouet (2001). Trends in long-period and tremor seismicity related to magmatic fluid compositions J. Volcanological and Geothermal Research 108: 265-281.

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Savage. W.Z., M.M.Morrissey, R.L.Baum (2000). Geotechnical properties for lanslide-prone Seattle-area glacial deposits. U.S. Geol. Surv. Open File Rep.00-228. pp. 01-5.

Morrissey, M.M., L.G. Mastin (2000). Vulcanian Eruptions. In: Encyclopedia of Volcanoes, Ed. H. Sigurdsson, Academic Press, San Diego, CA, pp. 463-475.

Morrissey, M.M., B.Zimanowski, K. Wohletz (2000). Phreatomagmatic Fragmentation. In: Encyclopedia of Volcanoes, Ed. H. Sigurdsson, Academic Press, San Diego, CA, pp. 431-445.

Wieczorek, G.F., Snyder, J.B., Waitt, R.B., Morrissey, M.M., Uhrhammer, R., Harp, E.L., Norris, R.D., Bursik, M.I., and Finewood, L.G. (2000). The unusual air blast and dense sandy cloud triggered by the July 10, 1996, rock fall at Happy Isles, Yosemite National Park, California, G.S.A. Bull. 112:75-85.

M. Garcés, M. Iguchi, K. Ishihara, M. Morrissey, Y. Sudo, and T. Tsutsui (1999). Infrasonic precursors to a Vulcanian eruption at Sakurajima Volcano, Japan. Geophysical Research Letters, 26: 2537-2540.

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Kieffer, S.W., M.M. Morrissey (1993). Exploring Earth with new data and tools. Geotimes 38:15-17.

Morrissey, M.M. (1990). SEM analysis of tephra from the 1989-1990 eruption of Redoubt Volcano, Alaska. Alaska Volcano Observatory Circular, March 1990: 10-17.

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ATTACHMENT 24

EVERETT L. REDMOND II, Ph.D.

EDUCATION

- Massachusetts Institute of Technology, Ph.D., Nuclear Engineering and a Minor in Biology, 1997
- Massachusetts Institute of Technology, M.S., Nuclear Engineering, 1990
- Massachusetts Institute of Technology, B.S., Nuclear Engineering, 1990

PROFESSIONAL HISTORY

- Nuclear Energy Institute, Washington, DC, Senior Project Manager, 2006-Present
- Holtec International, Marlton, NJ, Principal Engineer, 1995-2006
- Los Alamos National Laboratory, Los Alamos, NM, Graduate Research Assistant, Summers 1993 and 1994
- Raytheon, Sudbury, MA, Shielding Consultant, Spring 1993
- Northeast Utilities Company, Hartford, CT, Engineer, Summer 1992
- Idaho National Engineering Laboratory, Idaho Falls, ID, Engineer and Co-op Student, 1987-1990

AFFILIATIONS AND AWARDS

- Technical Reviewer, DOE Nuclear Engineering Education Research Proposals (2006)
- Member, American Nuclear Society (1986-Present)
- Member, MIT Educational Council with responsibility for interviewing prospective MIT undergraduates.
- MIT Knapp Fellowship 1992
- Avid Scuba Diver (PADI Instructor since 2006)

REPRESENTATIVE EXPERIENCE

- Ten years of experience performing shielding and criticality calculations and reviews of spent fuel storage systems.
- Twelve years of experience interacting with the Nuclear Regulatory Commission on licensing activities related to spent fuel storage systems.
- Two summers of experience working with the group that developed the Monte Carlo code MCNP at Los Alamos National Laboratory. MCNP is used to perform shielding and criticality calculations.

RESPREPRESENTATIVE PROJECTS

Nuclear Energy Institute
Organized the commercial nuclear power industry's position on emergent generic issues and presented these positions to the Nuclear Regulatory Commission. Presented industry's position on burnup credit to the Nuclear Regulatory Commission's Advisory Committee on Nuclear Waste and Materials.

Holtec International
Performed spent fuel pool criticality analysis for PWR and BWR spent fuel pools to license spent fuel pool expansion projects with the Nuclear Regulatory Commission. Reviewed numerous criticality analyses for spent fuel pool storage expansion projects. Participated in reviews and meetings with the NRC for licensing burnup credit for spent fuel transportation under 10 CFR 71. Developed shielding analysis methods and performed all shielding analyses for licensing Holtec's dual-purpose HI-STAR 100 System for storage and transportation and Holtec's HI-STORM 100 System for storage with the USNRC

under 10CFR71 and 10CFR72 regulations. Developed technical approach and performed numerous site specific dose evaluations to comply with 10CFR72 dose requirements.

SELECTED PUBLICATIONS

E.L. Redmond II and M. Marionneaux, "Measured and Calculated Dose Rates Around the HI-STORM 100 Dry Cask Storage System," Proceedings of the 12th Biennial RPSD Topical Meeting, Santa Fe, NM, April 14-18, 2002.

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E.L. Redmond II, "Multigroup Cross Section Generation Via Monte Carlo Methods," Doctoral Thesis, Massachusetts Institute of Technology (1997).

R. Zamenhof, E. Redmond II, G. Solares, D. Katz, K. Riley, S. Kiger, and O. Harling, "Monte-Carlo-Based Treatment Planning for Boron Neutron Capture Therapy Using Custom Designed Models Automatically Generated From CT Data," *Int. J. Radiation Oncology Biol. Phys.*, 35, 383-397 (1996).

O.K. Harling, R.D. Rogus, E.L. Redmond II, K.A. Roberts, D.J. Moulin and C.S. Yarn, "Phantoms for Neutron Capture Therapy Dosimetry," presented at Sixth International Symposium on Neutron Capture Therapy for Cancer, Kobe, Japan, October 31 - November 4, 1994.

J.C. Wagner, E.L. Redmond II, S.P. Palmtag, J.S. Hendricks, "MCNP: Multigroup/Adjoint Capabilities," LA-12704, Los Alamos National Laboratory (1994).

E.L. Redmond II, J.C. Yanch, and O.K. Harling, "Monte Carlo Simulation of the MIT Research Reactor," *Nuclear Technology*, *106*, 1, April 1994.

E.L. Redmond II and J.M. Ryskamp, "Monte Carlo Methods, Models, and Applications for the Advanced Neutron Source," *Nuclear Technology*, *95*, 272, (1991).

R.C. Thayer, E.L. Redmond II, and J.M. Ryskamp, "A Monte Carlo Method to Evaluate Heterogeneous Effects in Plate-Fueled Reactors," *Trans. Am. Nucl. Soc*., *63*, 445, (1991).

J.M. Ryskamp, E.L. Redmond II and C.D. Fletcher, "Reactivity Studies on the Advanced Neutron Source Preconceptual Reactor Design," *Proc. Topl. Mtg. Safety of Non-Commercial Reactors*, Boise, ID, October 1-4, 1990, Vol. I, p. 337 (1990).

E.L. Redmond II and J.M.Ryskamp, "Monte Carlo Methods, Models, and Applications for the Advanced Neutron Source," *Trans. Am. Nucl. Soc*., *61*, 377 (1990).

E.L. Redmond II, "Monte Carlo Methods, Models, and Applications for the Advanced Neutron Source," Masters Thesis, Massachusetts Institute of Technology (1990).

E.L. Redmond II and J.M. Ryskamp, "Design Studies on Split Core Models with Involute Fuel for the Advanced Neutron Source," NRRT-N-88-034, Idaho National Engineering Laboratory (1988).

ATTACHMENT 25

FRASER KING, Ph.D., FNACE

EDUCATION

- University of London, Imperial College, London, U.K.: Ph.D. Chemistry, 1978-1981
- University of London, Imperial College, London, U.K.: B.S. Chemistry, 1975-1978

PROFESSIONAL HISTORY

- Integrity Corrosion Consulting Ltd., Calgary, AB, Canada, President & Principal Consultant, 1999-Present
- NOVA Chemicals, NOVA Chemicals Research & Technology Centre, Calgary, AB, Canada, Senior Scientist, Environment and Corrosion, 1999-2007
- Atomic Energy of Canada Limited, Pinawa, MB, Canada, Corrosion Scientist/Applied Electrochemist, 1984-1999
- Central Electricity Generating Board, CERL, Leatherhead, U.K, Corrosion Scientist, 1981-1984

AFFILIATIONS AND AWARDS

- National Association of Corrosion Engineers (NACE International)
- NACE International Research Committee (2004)
- Electrochemical Society
- Canadian Institute

REPRESENTATIVE EXPERIENCE

- Dr. King has 25 years experience in corrosion, materials science, and applied electrochemistry in the nuclear and oil and gas industries.
- Dr. King's research interests include: corrosion, applied electrochemistry, lifetime prediction, safety and risk assessments, reactive-transport modelling, environmental impact analysis, the design, fabrication, and performance of nuclear waste containers, the performance of used nuclear fuel under disposal conditions, corrosion of reactor and steam generator components, and the chemical cleaning of nuclear steam generators.

REPRESENTATIVE PROJECTS

Integrity Corrosion Consulting Limited
Since 1999, Dr. King has been President of Integrity Corrosion Consulting Limited. He is the lead OPG consultant for the development of lifetime prediction models for copper and C-steel waste containers in both crystalline rock and sedimentary deposits. OPG are currently assessing the feasibility of using C-steel as a waste package material as an alternative to copper. In addition, sedimentary deposits (sandstone or shale) may be considered as an alternative to crystalline rock for the host geological formation. Dr. King is also a consultant for nuclear waste management programs in Sweden, Switzerland, Finland, Japan, and the IAEA in the areas of waste container performance and used fuel alteration. More recently, he has also become involved in the assessment of the performance of L&ILW **[what is this acronym?]** containers during both storage and disposal in a deep underground repository.

Atomic Energy of Canada Limited (AECL)
Dr. King was Technical Program Leader for copper corrosion studies for AECL's deep underground repository program for 15 years. His work on the corrosion of copper lead to the adoption of this material as the reference container material for the disposal of nuclear waste for Ontario Power Generation's (OPG) Deep Geologic Repository Program. As part of this program, Dr. King has developed models for

uniform corrosion, stress corrosion cracking (SCC) , microbiologically influenced corrosion (MIC), and under-deposit corrosion of copper containers. These models are now being extended to C-steel and passive materials, such as Alloy 22.

Dr. King was a co-author of the 1994-1996 Environmental Impact Statement (EIS) for AECL's deep underground nuclear fuel waste management program and was involved in public hearings and consultations on the proposed concept. This program was succeeded by the OPG Deep Geologic Repository program, which is currently being reviewed, along with other options, by the Nuclear Waste Management Office (NWMO) and the Government of Canada.

Electric Power Research Institute (EPRI)
Dr. King is currently Technical Leader on containment issues for EPRI's independent analysis of the high-level waste repository at Yucca Mountain, Nevada, U.S. He has responsibility for developing lifetime prediction models for the Alloy 22 waste packages and Titanium drip shields. Various corrosion processes are taken into account, including uniform corrosion, localized (crevice) corrosion, SCC, MIC, and hydrogen-induced cracking (for Ti only). Separate analyses are being developed for both the nominal scenario and seismic and igneous disruptive events. Dr. King is also leading a revision of EPRI’s treatment of Zircaloy corrosion, used fuel alteration and radionuclide release models.

Oil & Gas Pipeline and Petrochemical Industries
Over the past nine years, Dr. King has also worked extensively in the oil and gas pipeline and petrochemicals industries. He has established and managed a program in pipeline corrosion funded by a range of companies and organizations, including TransCanada Pipelines, NOVA Chemicals, the Pipeline Research Council International (PRCI), the Gas Technology Institute (GTI), and the Canadian Energy Pipeline Association (CEPA). He currently manages a program of 30-35 projects with total funding of $2-3M. His pipeline-related interests include: pipeline and chemical plant integrity, stress corrosion cracking (initiation and propagation), external corrosion, internal corrosion, coatings, repair techniques, field measurements of pipe-depth environments, cathodic protection, model development, failure investigation, inhibitor selection and performance, failure analysis, and diagnostic methods for fouling of turbines at compressor stations.

SELECTED PUBLICATIONS

Journal Papers

F. King, M. Kolar, and J.H. Kessler, “ERI’s Engineered Barrier System Corrosion Model (EBSCOM),” Nucl. Technol., submitted.

M.W. Kozak, G. Mungov, M.J. Apted, D. Langmuir, F. King, and J.H. Kessler, “An Independent Total System Performance Assessment of Yucca Mountain,” Nucl. Technol., submitted.

J. Smith, Z. Qin, F. King, L. Werme, and D.W. Shoesmith, “Sulphide Film Formation on Copper under Electrochemical and Natural Corrosion Conditions,” Corrosion, in press.

M. Apted, F. King, D. Langmuir, R. Arthur, and J. Kessler, “The unlikelihood of localized corrosion of nuclear waste packages arising from deliquescent brine formation,” Journal of Materials 57, 2005, 43-48.

Z. Qin, B. Demko, J. Noël, D. Shoesmith, F. King, R. Worthingham and K. Keith, "Localized dissolution of millscale-covered pipeline steel surfaces," Corrosion 60, 906-914, 2004.

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D.W. Shoesmith, M. Kolar, and F. King, "A mixed-potential model to predict fuel (uranium dioxide) corrosion within a failed nuclear waste container," Corrosion, 59, 802-816, 2003.

S. Stroes-Gascoyne, F. King, J.S. Betteridge, and F. Garisto, "The effects of alpha-radiolysis on UO_2 dissolution determined from electrochemical experiments with ^{238}Pu-doped UO_2," Radiochimica Acta 90, 603-609, 2002.

W. Chen, F. King, and E. D. Vokes, "Characteristics of Near Neutral pH Stress Corrosion Cracks in an X-65 Pipeline Steel", Corrosion, 58(3), (2002) 267-275.

S.-H. Wang, W. Chen, F. King, T.R. Jack, and R.R. Fessler, "Precyclic-loading-induced stress corrosion cracking of pipeline steels in a near-neutral-pH soil environment," Corrosion 56(6), 526-537, 2002.

W. Chen, F. King, T. Jack, M. L. Wilmott, "Environmental Aspects of Neutral pH SCC of Pipeline Steel", Metall. and Mater. Trans., 33A(5), (2002) 1429-1437.

D.W. Shoesmith, W.H. Hocking, B.M. Ikeda, F. King, J.J. Noel and S. Sunder, "Application of electrochemical methods in the development of models for fuel dissolution and container corrosion under nuclear waste disposal conditions," Can. J. Chem. 75, 1566-1584 (1997).

F. King, C.D. Litke, M.J. Quinn and D.M. LeNeveu, "The measurement and prediction of the corrosion potential of copper in chloride solutions as a function of oxygen concentration and mass-transfer coefficient," Corros. Sci. 37, 833-851 (1995).

F. King, M.J. Quinn and C.D. Litke, "Oxygen reduction on copper in neutral NaCl solution," J. Electroanal. Chem. 385, 45-55 (1995).

F. King, C.D. Litke and Y. Tang, "Effect of interfacial pH on the reduction of oxygen on copper in neutral $NaClO_4$ solution," J. Electroanal. Chem. 384, 105-113 (1995).

F. King, "A natural analogue for the long-term corrosion of copper nuclear waste containers - reanalysis of a study of a bronze cannon," Appl. Geochem. 10, 477-487 (1995).

D.W. Oscarson, H.B. Hume and F. King, "Sorption of cesium on compacted bentonite," Clays Clay Minerals 42, 731-736 (1994).

F. King, C.D. Litke and S.R. Ryan, "A Mechanistic Study of the Uniform Corrosion of Copper in Compacted Na-Montmorillonite/Sand Mixtures", Corros. Sci. 33, 1979-1995 (1992).

F. King, B.M. Ikeda and D.W. Shoesmith, "Nuclear Waste: Can We Contain It?", CHEMTECH, 22, 214 (1992).

F. King, "Magnetite Spherule Golf Ball", J. Irreproducible Results, 36, 19 (1991).

F. King and M. Spiro, "Transference Numbers and Phenomenological Transport Coefficients for Concentrated Aqueous Hydrochloric Acid Solutions at 25°C", J. Solution Chem., 12, 65 (1983).

F. King and M. Spiro, "Modification of the Direct Moving Boundary Method for the Determination of Transference Numbers for Concentrated Solutions", J. Solution Chem., 10, 881 (1981).

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F. King, “Application of Rotating Electrode Techniques to Corrosion Studies,” in Techniques for Corrosion Monitoring, L. Yang (ed.), Woodhead Publishing (Cambridge, U.K.), in preparation.

W. Chen, T. Jack and F. King, "Corrosions and Erosions in Pipes" in Fluid Flow Handbook, ed. J. Saleh, McGraw-Hill, 2002.

D.W. Shoesmith, B.M. Ikeda, F. King and S. Sunder, "Prediction of long-term behaviour for radioactive nuclear waste disposal," in CORROSION/96 Research Topical Symposia, NACE International, (Houston, TX, 1996), p. 101-134. (Also published as Atomic Energy of Canada Limited Report, AECL-11580, COG-96-187 (1996)).

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M. Spiro and F. King, "Transport Properties in Concentrated Aqueous Electrolyte Solutions", in Ionic Liquids (D. Inman and D.G. Lovering, eds.) Plenum Press, New York, Chapter 5 (1981).

Refereed Conference Papers

F. King, R. Arthur, M. Apted, and J. Kessler. 2007. Potential for the Localized Corrosion of Alloy 22 Waste Packages in Ternary and Quaternary Deliquescent Brines in the Yucca Mountain Repository. In Proc. Waste Management 2006, February 25 – March 1, 2007, Tucson, AZ (University of Arizona, Tucson, AZ), submitted.

Apted, M.J., J. Kessler, F. Schwartz, W. Zhou, F. King, J. Kemeny, B. Ross, and A. Ross. 2007. Analysis of the Maximum Disposal Capacity for Commercial Spent Nuclear Fuel in a Yucca Mountain Repository. In Scientific Basis for Nuclear Waste Management XXX, Mat. Res. Soc. Symp. Proc. (Materials Research Society, Warrendale, PA), submitted.

King, F. and M. Kolar. 2006. EPRI's Engineered Barrier System Corrosion Model (EBSCOM). In Proc. 11th International High-level Radioactive Waste Management Conference, American Nuclear Society (La Grange Park, IL), pps. 478-485.

King, F., R. James, S. Findlan, M. Apted, and J. Kessler. 2006 Performance of the Waste Package During an Igneous Disruptive Event. In Proc. 11th International High-level Radioactive Waste Management Conference, American Nuclear Society (La Grange Park, IL), pps. 835-842.

Kozak, M.W., M. Apted, M. Morissey, F. King, J. Kessler, and G. Mungov. 2006 Consequences Associated with Igneous Activity at Yucca Mountain. In Proc. 11th International High-level Radioactive Waste Management Conference, American Nuclear Society (La Grange Park, IL), pps. 170-176.

R. James, F. King, and J. Kessler. 2006 The Consequence of Seismic Activity on Waste Package Structural Integrity. In Proc. 11th International High-level Radioactive Waste Management Conference, American Nuclear Society (La Grange Park, IL), pps. 913-920.

Apted, M.J., D. Langmuir, and F. King. 2006 Evaluation of Potential Formation and Impacts of Deliquescent Brines. In Proc. 11th International High-level Radioactive Waste Management Conference, American Nuclear Society (La Grange Park, IL), pps. 921-924.

Kessler, J., M. Apted, J. Kemeny, F. King, A.M. Ross, B. Ross, F.W. Schwartz, and W. Zhou. 2006. Room at the mountain: estimated maximum amounts of commercial spent nuclear fuel capable of

disposal in a Yucca Mountain repository. In Proc. ICONE 14, International Conference on Nuclear Energy, American Society of Mechanical Engineers (New York, NY), Paper ICONE14-89857.

Apted, M., M. Kozak, W. Zhou, J. Kemeny, F. King, D. Martin, R. James, M. Stirling, M. Morrisey, B. Ross, and J. Kessler. 2006 Independent analysis of seismicity and rockfall scenarios for the Yucca Mountain repository. In Proc. Waste Management 2006, February 26 – March 2, 2006, Tucson, AZ (University of Arizona, Tucson, AZ), paper 6163.

Apted, M., J. Kessler, M. Morrisey, F. King, W. Zhou, M. Kozak, and F. Schwartz. 2006. Potential igneous processes relevant to the Yucca Mountain Repository: intrusive-release

Scenario. In Proc. Waste Management 2006, February 26 – March 2, 2006, Tucson, AZ (University of Arizona, Tucson, AZ), paper 6086.

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ATTACHMENT 26

THOMAS E. MAGETTE, P.E.

EDUCATION

- University of Tennessee, Knoxville, TN: M.S., Nuclear Engineering, 1979
- University of Tennessee , Knoxville, TN: B.S., with Honors, Nuclear Engineering, 1977

PROFESSIONAL HISTORY

- Energy*Solutions*, LLC, Washington, DC, Senior Vice President, 2006-Present
- Energy*Solutions*, LLC, Columbia, MD, Vice President, 2005
- Environmental Resources Management, Inc., Annapolis, MD, Senior Consultant 2003- 2005
- Tetra Tech, Inc., Alexandria, VA, Vice President, 1994-2003
- Tetra Tech, Inc., Alexandria, VA, Director, 1993-1994
- Tetra Tech, Inc., Alexandria, VA, Associate Director, 1993
- U.S. Department of Energy, Office of New Production Reactors, Office of Safety and Quality, Nuclear Safety Division, Washington, DC, Division Director, 1992-1993
- U.S. Department of Energy, Office of New Production Reactors, Office of Safety and Quality, Nuclear Safety Division, Standards and Policies Branch, Washington, DC, Branch Chief, 1991-1992
- U.S. Department of Energy, Office of New Production Reactors, Office of Safety and Quality, Nuclear Safety Division, Washington, DC, Nuclear Engineer, 1990-1991
- Maryland Department of Natural Resources, Power Plant Research Program, Annapolis, MD, Manager of Nuclear Programs, 1988-1990
- Maryland Department of Natural Resources, Power Plant Research Program, Annapolis, MD, Administrator of Site Evaluation, 1985-1988
- Maryland Department of Natural Resources, Power Plant Research Program, Annapolis, MD, Administrator of Nuclear Evaluations and Transmission Line Review, 1979-1985
- Oak Ridge National Laboratory, Instrumentation and Controls Division, Oak Ridge, TN, Research Assistant, 1977-1979

AFFILIATIONS AND AWARDS

- Registered Professional Engineer, Maryland (18515); Virginia (025042); New Mexico (14018)
- DOE Q Clearance (Inactive); DoD Secret Clearance (Inactive)
- Member, American Nuclear Society
- Member, Society of American Military Engineers

REPRESENTATIVE EXPERIENCE

- Twenty five years experience managing and conducting environmental assessment, siting, and nuclear safety programs for a wide variety of energy generation, transmission, and defense facilities.
- Extensive experience in all phases of environmental compliance for energy facilities; developed and applied criteria for siting a variety of energy generation and transmission facilities and successfully defended their application as an expert testimony in regulatory proceedings.
- Extensive experience managing the preparation of NEPA analyses and documents for several highly controversial projects, including the siting and licensing of power plants, defense nuclear reactors, nuclear weapons manufacturing facilities, high-voltage transmission lines, natural gas

distribution lines, and biosafety level IV facilities. Managed the preparation of over 50 EISs and EAs, including 19 EISs and 18 EAs for DOE projects.

REPRESENTATIVE PROJECTS

*Energy*Solutions
Mr. Magette is responsible for business development and regulatory strategy for the Commercial Services Group, a $130M business line. He manages development of new programs and initiatives within the commercial nuclear industry including budget development and analysis and managing and coordinating activities required to obtain NRC licensing. He has developed the regulatory strategy for ES' innovative solution to decommission nuclear power plants called the "License Stewardship Program," in which ES acquires a shutdown nuclear power plant from a utility. The NRC transfers the Part 50 license to ES and ES, as the licensee, performs decommissioning using the dedicated decommissioning trust fund, and returns unused funds to the public via the utility. The initial application of this approach is underway at the Zion nuclear station.

Environmental Resources Management, Inc.
Mr. Magette managed the government group and lead a new initiative to significantly increase ERM's presence in the Federal consulting marketplace. He prepared and implemented Federal Business Development Strategy and served as capture lead for proposals to the U.S. Army Corps of Engineers, U.S. Air Force, Department of Energy, U.S. Trade and Development Agency, and U.S. Park Service. He also served as Project Manager to identify potential sites for an offshore LNG facility, and developed a novel methodology to identify a preferred site in open water setting for first offshore terminal on the Eastern Seaboard. Mr. Magette also developed the siting methodology for a high-voltage transmission line and successfully defended its application as an expert witness in licensing hearings.

Tetra Tech, Inc.
As Vice President, Mr. Magette was responsible for growing and subsequently managing a project office into the second-largest multi-office cost center within Tetra Tech, with offices in 5 states. He served as Program Manager for several large Department of Energy contracts, including the $100M Stockpile Stewardship Program for the National Nuclear Security Administration, $100M Environmental Management Program, and the $50M DOE-Wide NEPA Program, $27M Fissile Materials Disposition Program, and the $45M Nuclear Weapons Complex Reconfiguration Program (also served as capture lead for NNSA and DOE-Wide NEPA Programs). He managed EISs at several NNSA sites, including LANL, Y-12, Pantex, and the Nevada Test Site. He broadened the client base from DOE to include over a dozen additional Federal agencies and commercial clients. He served as Project Manager for several energy-related projects and provided expert witness testimony for licensing hearings.

While serving as Director, Mr. Magette was the Program Manager for the DOE Nuclear Weapons Complex Reconfiguration Environmental Support Program. He was responsible for the preparation of the Tritium Supply and Recycling Programmatic Environmental Impact Statement. He also served as Manager of the Alexandria office, directing all technical and business development activities.

While serving as Associate Director, Mr. Magette was the Deputy Program Manager for the Reconfiguration Program and Deputy Manager of Alexandria office, directing all technical activities.

U.S. Department of Energy
As Director of the Nuclear Safety Division, Mr. Magette directed the activities of a 15-person division responsible for assessing nuclear safety of the new production reactors, including establishing policy, developing a safety review basis, and conducting reviews. He developed a safety review basis that included setting nuclear safety requirements, developing safety analysis report (SAR) format and content

guidance, and developing SAR acceptance criteria that satisfied both DOE requirements and safety standards of the commercial nuclear power industry. In this position, he addressed controversial issues, e.g., treatment of severe accidents in SARs and application of probabilistic risk assessment in safety reviews. He managed contractors ($10M/year), including Los Alamos National Laboratory, to support these activities.

While serving as Chief of the Standards and Policies Branch in the Nuclear Safety Division, Mr. Magette managed the branch responsible for development of nuclear safety review basis. He prepared a staffing plan to develop division capability to review the NPR SAR and prepare safety evaluation report, including creation of branch structure, assignment of disciplines and staff within branches, recruitment and acquisition of staff. He managed staff with the following nuclear safety review responsibilities: radiation protection, metallurgy, seismology, operating experience, QA, and technical liaison with oversight organizations.

As a Nuclear Engineer in the Nuclear Safety Division, Mr. Magette conducted safety analyses and served as liaison with oversight organizations, including Defense Nuclear Facilities Safety Board, DOE Office of Nuclear Safety, and Advisory Committee on Nuclear Facility Safety. He reviewed DNFSB recommendations and staff reports for applicability to NPR, and analyzed nuclear safety aspects of all NPR environmental reports and requirements documents. He directed a review of safety aspects of NPR EIS. His additional responsibilities included: developing operating experience program, establishing safety review schedules, and analyzing application to NPR of new DOE rules and orders.

Maryland Department of Natural Resources, Power Plant Research Program
Mr. Magette established the Nuclear Program, combining activities that formerly were spread throughout the agency. As Manager, he was responsible for managing all nuclear power related activities of the agency, including radiological emergency planning and response, radiological environmental monitoring, operation of the Radiation Chemistry Laboratory, safety inspections of the Calvert Cliffs and Peach Bottom nuclear power plants, review of proposed license amendments for Calvert Cliffs, coordination with the Nuclear Regulatory Commission on regulatory and safety issues, review of proposed NRC rules, and development of state policy on nuclear power issues. He also participated in NRC team inspections for Calvert Cliffs & Peach Bottom and was badged for unrestricted access at both plants. Mr. Magette was responsible for conducting environmental licensing reviews of power plants. Major projects managed include licensing of new coal fired power plant at Perryman and evaluation of health effects of 500 kV transmission line electromagnetic fields.

As Administrator of Site Evaluation, Mr. Magette was responsible for conducting comprehensive environmental reviews of power plants proposed for construction in Maryland. He reviewed all potential impacts, including air quality, groundwater supply and quality, surface water intake and discharge, solid waste disposal, alternative sites review, ecological impacts, socioeconomics, and all economic issues, such as need for power, least cost planning, and load forecasting. He evaluated all permitting issues, including compliance with applicable state and federal environmental statutes. His projects managed included licensing of a new generating facility at Chalk Point and a fuel-switching case for a new plant in Easton. He also retained responsibility for the activities of his previous position, described below.

As Administrator of Nuclear Evaluations and Transmission Line Review, Mr. Magette was responsible for radiological emergency planning and response activities, particularly accident assessment and dose projections. He participated in NRC working group to draft emergency planning guidelines. He participated in drafting state emergency plan to satisfy new NRC and FEMA regulations and guidelines, and conducted radiological monitoring at Calvert Cliffs and Peach Bottom. He participated in sampling program design, sample collection, data analysis and interpretation, and reporting. He also was responsible for conducting comprehensive environmental reviews of all transmission lines >69 kV proposed for construction in Maryland, and directed research projects to determine hazards associated with electric and magnetic fields from transmission lines.

Oak Ridge National Laboratory
As a Research Assistant in the Instrumentation and Controls Division, Mr. Magette was responsible for assisting in development of improvements to existing methods for condition monitoring of rotating equipment. He also investigated the potential for using fiber optic cable in high-radiation environments of nuclear power plants.

SELECTED PUBLICATIONS

J. T. Greeves, J. Lieberman, and T.E. Magette, Disposal of Large Reactor Components-Rulemaking to Address Funding of Disposal Costs, WM2008 Conference, February 2008, Phoenix, AZ.

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T.E. Magette, Petition for Rulemaking to Amend 10 C.F.R. § 2.802 to Permit the Disposal of Major Radioactive Components Using Decommissioning Trust Funds, May 29, 2007.

T.E. Magette, et al., Detailed Site Report for the Global Nuclear Energy Partnership Atomic City, Idaho Site, Energy*Solutions*, LLC, May 2007.

T.E. Magette, et al., Detailed Site Report for the Global Nuclear Energy Partnership Barnwell, South Carolina Site, Energy*Solutions*, LLC, May 2007.

T.E. Magette, et al., Detailed Site Report for the Global Nuclear Energy Partnership Roswell, New Mexico Site, Energy*Solutions*, LLC, May 2007.

T.E. Magette, Direct Testimony before the Public Service Commission of Maryland, Evaluation of an Application for the Urbana Loop 230 kV Transmission Line, August 12, 2005.

T.E. Magette, C. Faustini, D. Strebel, and P. Hall, Report from the Stakeholder Engagement Meeting for the Urbana Loop Transmission Line, Maryland Power Plant Research Program, August 2005.

R.I. McLean and T.E. Magette, "Radiological Impact," Power Plant Cumulative Environmental impact Report, Maryland Power Plant Research Program, PPRP-CEIR-5, 1986.

R.I. McLean, T.E. Magette and S.G. Zobel, Environmental Radionuclide Concentrations in the Vicinity of the Peach Bottom Atomic Power Station: 1979-1980, Maryland Power Plant Siting Program, PPSP-R-5, January 1983.

R.I. McLean, T.E. Magette and S.G. Zobel, Environmental Radionuclide Concentrations in the Vicinity of the Calvert Cliffs Nuclear Power Plant: 1978-1980, Maryland Power Plant Siting Program, PPSP-R-4, December 1983.

December 19, 2008

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of:	)	
	)	
U.S. Department of Energy	)	Docket No. 63-001
(High Level Waste Repository)	)	
	)	
	)	

CERTIFICATE OF SERVICE

I hereby certify that the foregoing "The Nuclear Energy Institute's Petition to Intervene" was served this date via the Nuclear Regulatory Commission's Electronic Information Exchange ("EIE"), which to the best of my knowledge transmitted the foregoing upon those on the Service List maintained by the EIE for the above-captioned proceeding.

Respectfully submitted,

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Dated: December 19, 2008

Counsel for NEI